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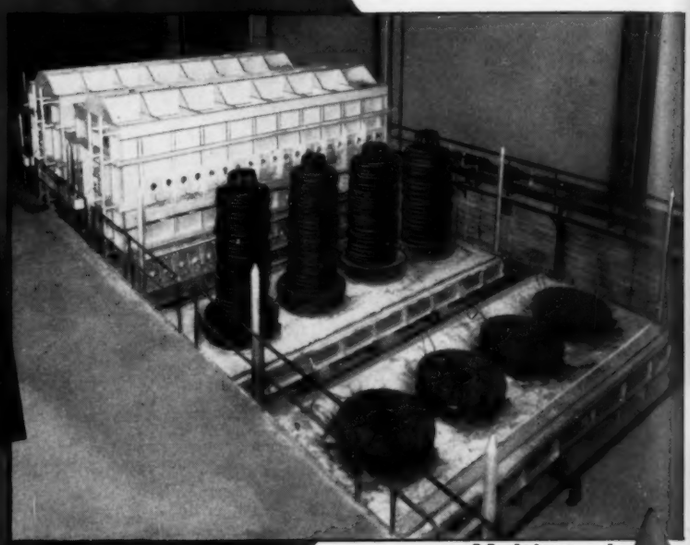

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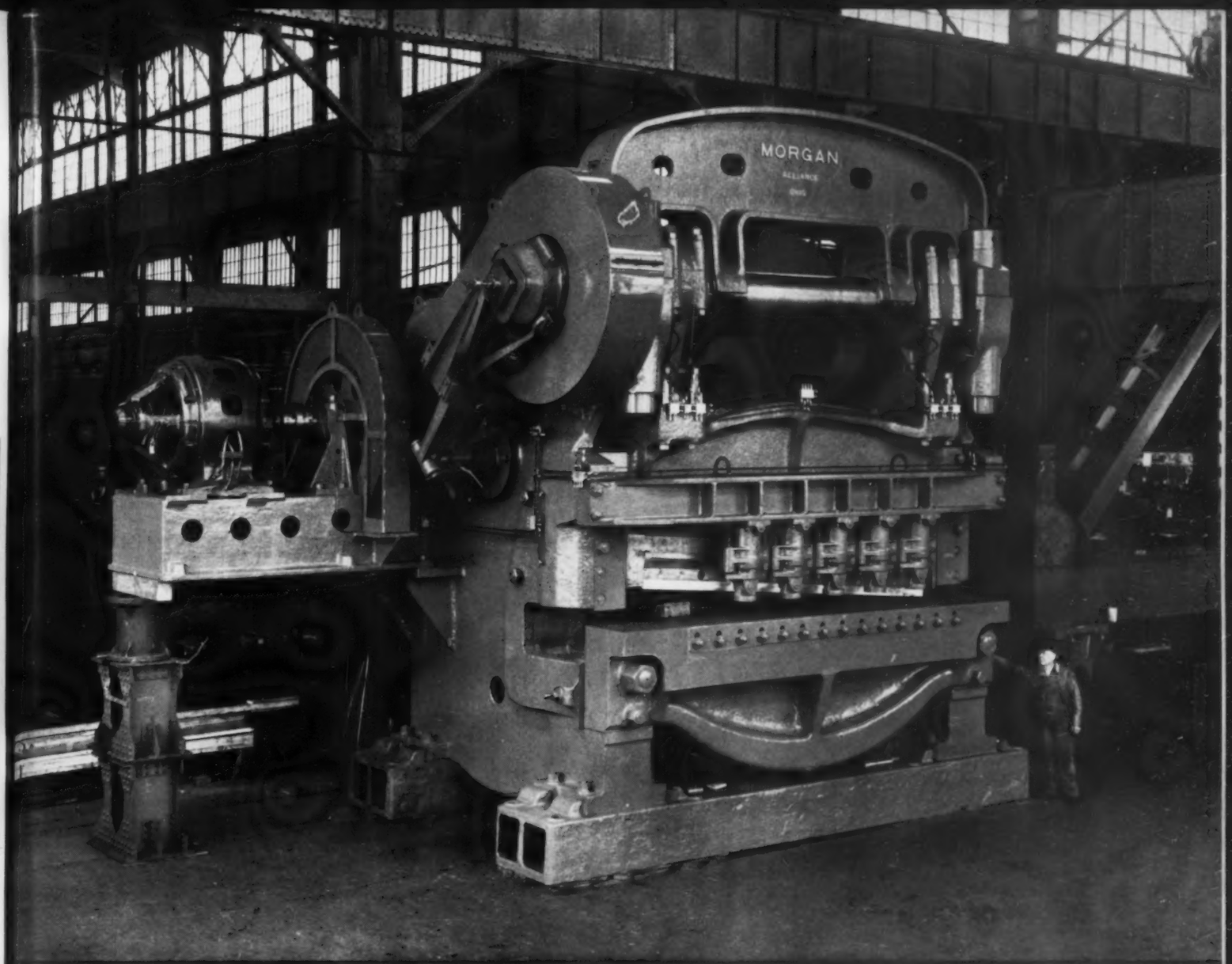

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MOTOR *Bearing* CHANGEOVERS

By A. A. Van Pelt

NORMA-HOFFMANN BEARINGS CORP.

PITTSBURGH, PA.

Presented before A. I. S. E.

PITTSBURGH DISTRICT SECTION

▲ THE popularity of ball and roller bearings for electric motors is evidenced by the greatly increased demand for them from the steel mills, coal mines, and industry in general. This popularity is recognized by the motor manufacturers and today almost any motor, regardless of its size or duty, is obtainable equipped with anti-friction bearings. There are, however, many thousands of the older motors, originally equipped with the old styles of sleeve bearings*, still in daily operation. While these old motors still give an excellent account of themselves, nevertheless there are many cases of abnormal maintenance costs which may be traced directly to the bearings, such as oil-soaked windings and commutators, and burned out bearings, with their attendant troubles.

The eminently satisfactory performance of the newer roller bearing-equipped motors naturally brought up the question "Why can't we put roller bearings in the old motors?" In general, the answer to this question is "You can!", and it is the purpose of this paper to show what our company has done along this line.

Before going into the various details of construction, let us point out that the roller bearings which we recommend in all of the following changeover designs are the cylindrical type in the single lip construction, Figure 1. This type of bearing is quite generally conceded to have the greatest radial load and shock capacity of any roller bearing of equivalent dimensions. It has also a relatively large intermittent thrust capacity more than ample for the normal requirements placed upon it, although it is not well adapted to continuous steady thrust loads of any great magnitude. It is therefore ideally suited for use in electric motors, which is attested to by the fact that this type of bearing has been the choice of motor manufacturers for years on the large high speed motors used in electric locomotives.

The outer races of the bearings are mounted approximately 1/16 in. off-center, giving a total operating clearance or end play of 1/8 in. This clearance is necessary to eliminate any possibility of endwise preload on the bearings, to take care of shaft expansion, and to com-

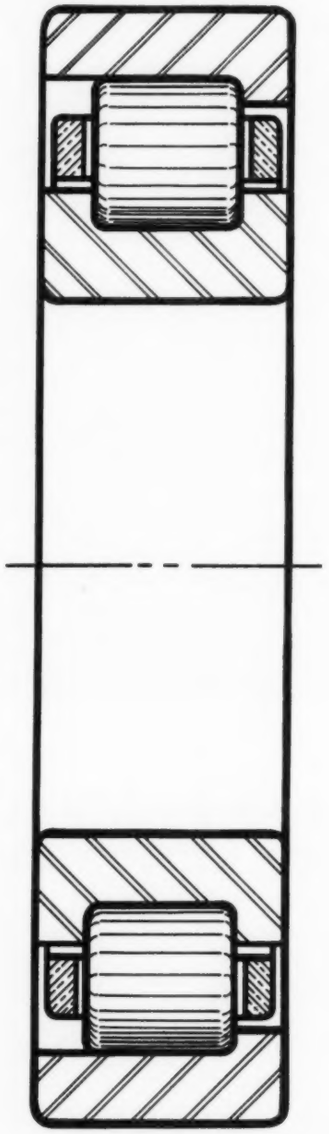


Figure 1

*Let it be pointed out here that the present day ball and roller bearings were not obtainable at the time many of these motors were built.

pensate for any slight errors in overall frame lengths or distance between shaft shoulders.

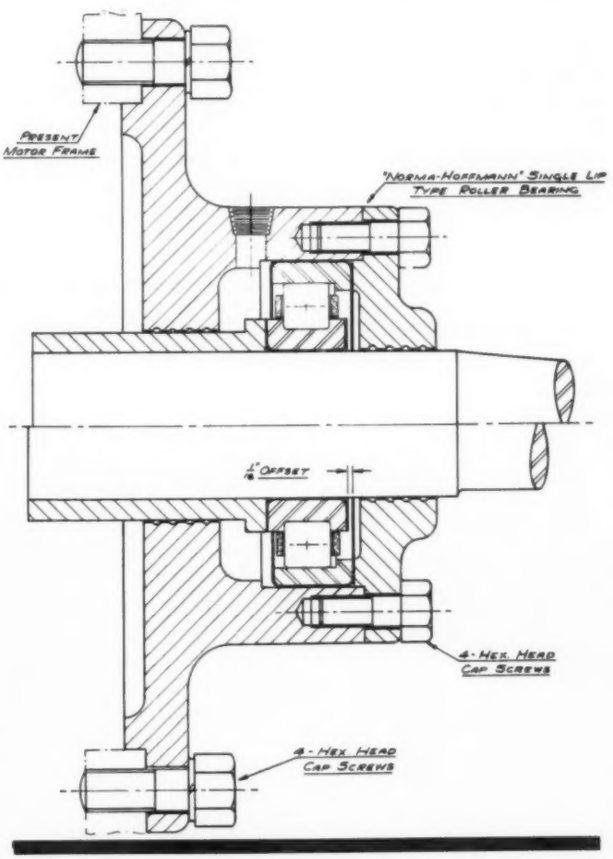
To apply the bearings to the shafts in the great majority of cases, a slight amount of metal is turned off, thereby permitting the use of the old shaft. As an example, a normal 3 in. diameter shaft is turned down to 2.9538 in., a 3¾ in. shaft to 3.7412 in., etc. In a very few cases the shafts must either be built up, generally by metal spraying, or replaced with a new shaft. This detail will be covered in the description of the individual motors.

CRANE MOTORS

The easiest type of motor to change over is the crane motor, such as the General Electric CO-1800 series or the Westinghouse K line. Both of these are split frame motors having the sleeve bearing housings bolted to each end of the frame. It is a very simple matter to replace these housings with others designed to accommodate roller bearings. Typical cross-section layouts are illustrated in Figure 2 and Figure 3 respectively. No machine work whatever is required on the frames of these two series of motors as the sleeve bearing housings are already machined to the identical dimensions required for the roller bearing housings.

In practically all sizes of both of these series of motors the existing shafts can be turned down a small amount to accommodate the bores of the roller bearings. As the remaining shaft shoulder is generally insufficient for a proper bearing shoulder, spacing sleeves are provided which extend from a definite shoulder along the shaft to the bearing. These changeovers are made very easily and at little cost as all of the work is done on the armature shaft, which can readily be handled even in a small repair shop.

Figure 2—Change over design of roller bearing flange unit for crane motors, etc.



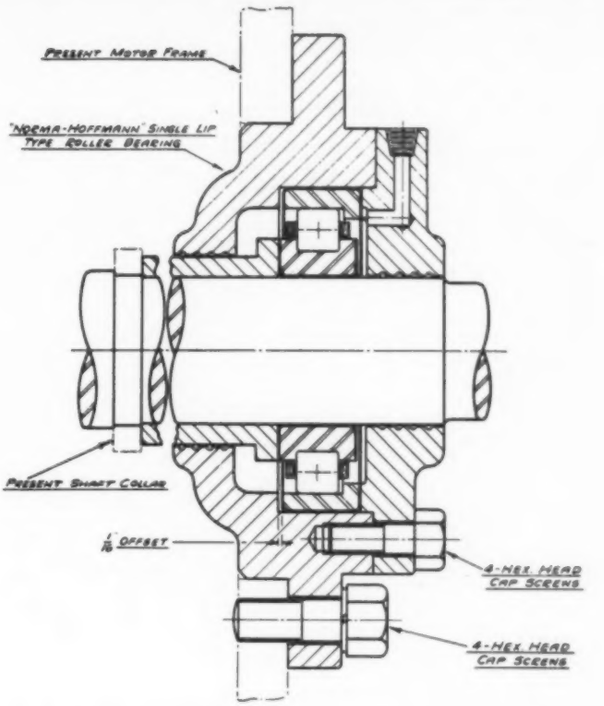
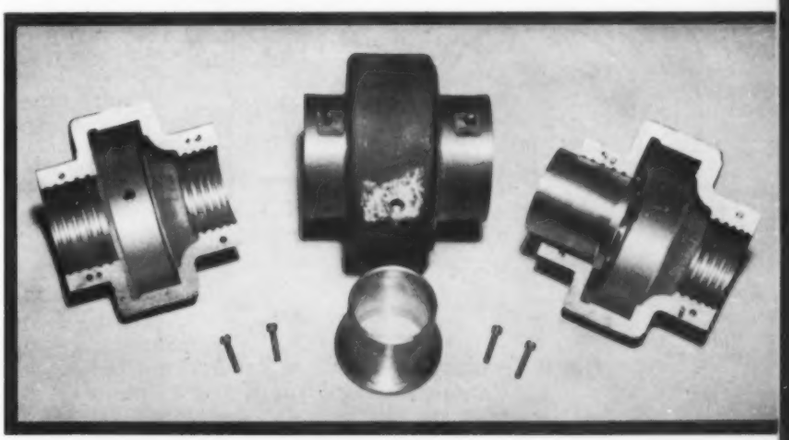


Figure 3—Another changeover design of roller bearing flange unit for crane motors, etc.

MILL MOTORS

While the crane motor type of changeover is the easiest to accomplish, the changeovers for mill motors are generally much more important to the average steel

Figure 5—Horizontally split cartridges for General Electric MD-102 mill motor.



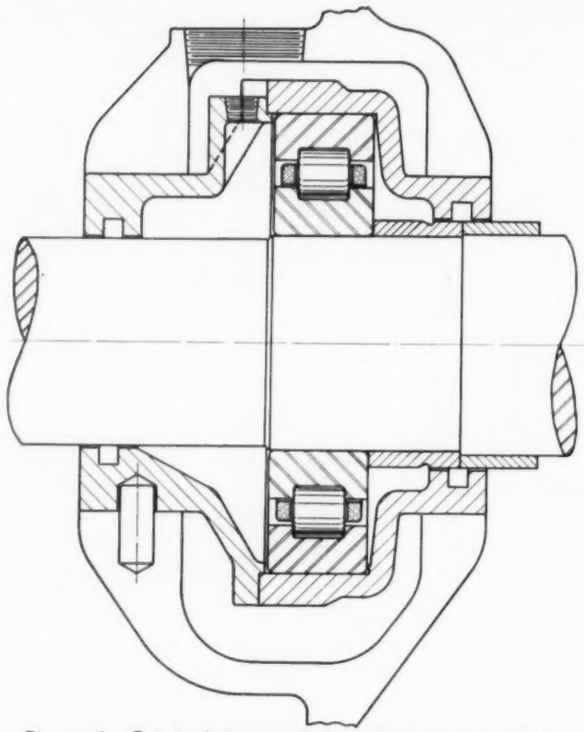


Figure 4—Original design of cartridge bearing housing.

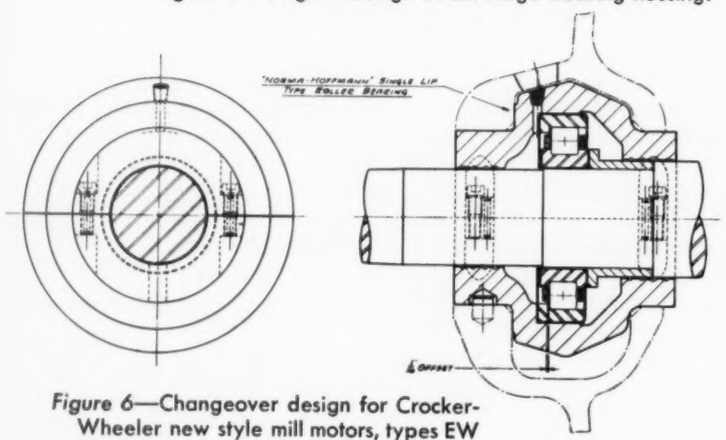


Figure 6—Changeover design for Crocker-Wheeler new style mill motors, types EW and FW.

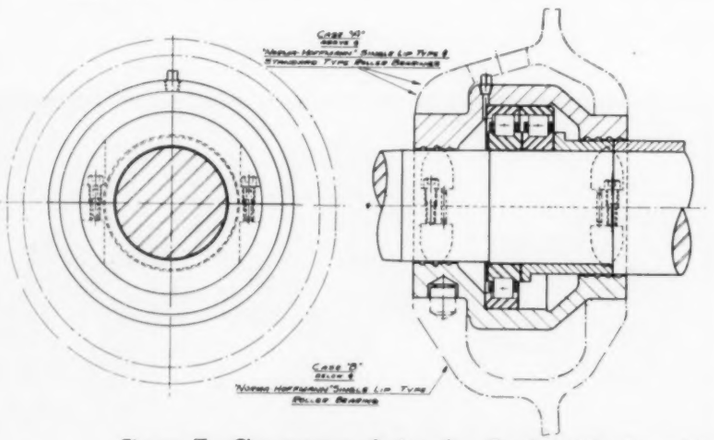

CASE "A" BELOW 8 "NORMA-HOFFMANN" SINGLE LIP TYPE ROLLER BEARING
CASE "B" BELOW 8 "NORMA-HOFFMANN" SINGLE LIP TYPE ROLLER BEARING

Figure 7—Changeover design for Crocker-Wheeler old-style mill motors, types EW and FW.

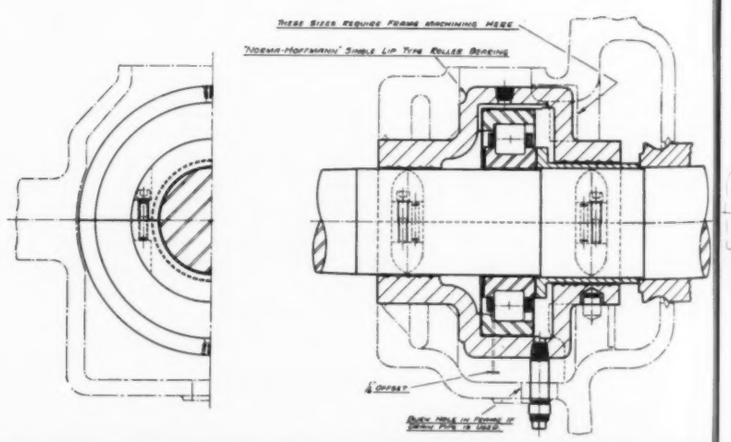
mill maintenance and electrical departments. These motors consist primarily of the Crocker-Wheeler AW to IW series, the General Electric MD-100 series, and the Westinghouse MT and MC series. These are also split frame motors, but with the section supporting the present sleeve bearings being an integral part of the frame. This particular section, which for lack of a better term will be called the "bearing supports," is indicated by the dot and dash outlines in the typical designs shown in Figures 6, 7, 8, 9, 10, and 11. In cross-section it consists essentially of an outer and an inner rib, each of considerable width, which have been the actual supports of the sleeve bearings.

It is necessary to remove some of the metal in either one or both of these ribs in most of the old mill motors to provide sufficient space for the cartridge or housing in which the roller bearing is mounted.

Before proceeding with a description of the design of cartridge housing which we have used since 1928 it might be well to consider our original, but now obsolete, design shown in Figure 4. In this arrangement the cartridge housing was split vertically, forming essentially a body and a cap, held together by a series of relatively small cap screws. An extended hub on both the housing and cap was the means of supporting this cartridge housing in the frame. While the design was quite simple and the machine work apparently quite easy, we soon found out in the laboratory which has the final say, namely the steel mill, that much was lacking. Numerous cases of slight eccentricity and out-of-parallelism between the two supporting hubs and the bore of the cartridge housing developed, but the most serious drawback was the repeated shearing of the cap screws. These were just as large as we could possibly make them in the very limited space available, but even so, they were not nearly large enough.

We then developed the designs which we use at present, Figures 5, 6, 7, 8, 9, 10, 11, in which the cartridge housing is split horizontally. We now feel that these designs are ideal because the results, extending back as far as 1928, have been very satisfactory. Very skillful machine work is necessary, but in spite of this, special

Figure 8—Changeover design for General Electric mill motors, MD-101 to MD-104½.



methods have been devised whereby an extremely accurate housing is provided at a cost practically equal to that of our previous design.

There are, of course, certain very specific advantages in this design of housing. A unit casting (bottom half) extends from support to support making it unnecessary to depend upon a few small cap screws to take all the hammering and shock loads imposed upon the motor. To date no cartridge housing has either given any trouble or broken apart in the many changeovers which have been made since 1928. Any thrust which may develop is taken directly from the outer race of the bearing through the metal in the cartridge housing to the solid metal in the outer rib or bearing support. In cases where dowel pins are used their only function is to prevent rotation of the cartridge housing. Any tendency toward rotation is practically eliminated if the frame bore is up to standard, as a clamp fit is thereby obtained ranging from .003 in. to .006 in. The long seal at each end of the cartridge housing, bored to a close clearance over the shaft diameter, has been found to be very effective in retaining grease and preventing the entrance of dirt.

Of extreme importance is the fact that practically all of these cartridge housings have been so designed that the old sleeve bearing shells can interchange directly. This means that while certain machine work must be done on the frame around the bearing supports, still no change is made in the standard bore or on the finished face at the inner side of the inner supporting rib where the thrust from the sleeve bearing is taken. Actually the limiting fits for the old sleeve bearing shells have not been disturbed and therefore the same sleeve bearing armature which has been used as a spare in the past can be mounted immediately in the roller bearing frame without any changes whatever. In the 38 different types and sizes of mill motors on which designs have been developed, one of the Westinghouse MT-5 designs is the only exception, and on this one size it only becomes necessary to provide special shells.

As there is considerable variation in the design of the sleeve bearing supports, not only between the different

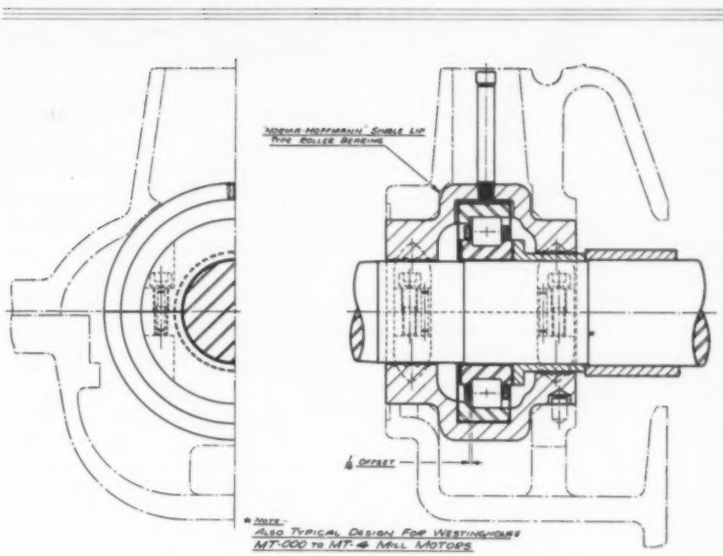

NORMA-HOFFMANN SINGLE LIP TYPE ROLLER BEARING
OFFSET
* NOTE-
ALSO TYPICAL DESIGN FOR WESTINGHOUSE MT-000 TO MT-4 MILL MOTORS

Figure 10—Changeover design for Westinghouse MC mill motors.

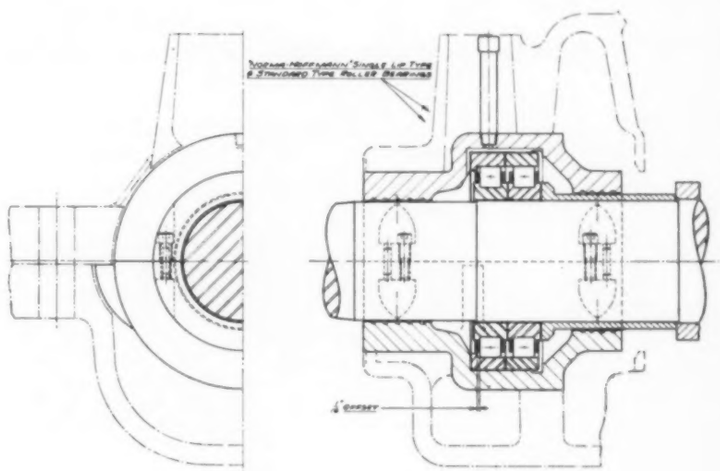


Figure 11—Changeover design for Westinghouse MT-5 and MT-6 mill motors.

Figure 9—Changeover for General Electric mill motors MD-105 to MD-110.

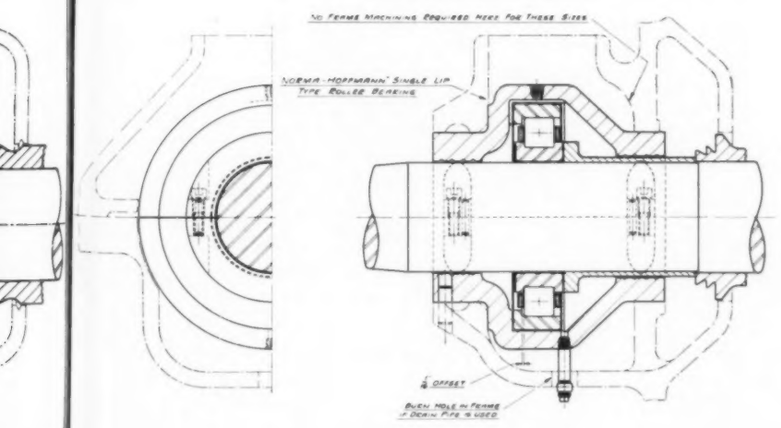
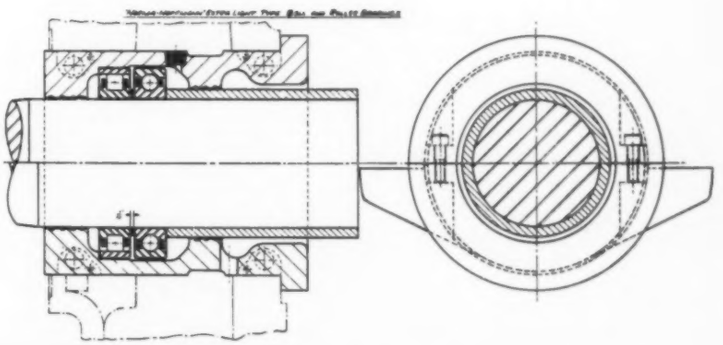

NO FRAME MACHINING REQUIRED HERE FOR THESE SIZES
NORMA-HOFFMANN SINGLE LIP TYPE ROLLER BEARING
OFFSET
BUSH HOLE IN FRAME IF DOWEL PIPE IS USED

Figure 12—Experimental changeover for Westinghouse MT-0 and MT-1 mill motors.



manufacturers but between different motor sizes of the same make, it appears desirable to illustrate the various mountings which have been developed. These will also indicate in a measure the necessary machine work.

The Crocker-Wheeler motors AW to IW, as shown in Figure 6 and Figure 7, require the least machine work. All that is necessary is to drill for the dowel pin and chamfer the inside corners of the two supporting ribs on each end. This chamfering can readily be done by means of a hand grinder or even by chipping with a cold chisel.

In the so-called "old style" frames, Figure 7, the space available in the top half in the sizes EW to IW is too small radially for the generally accepted medium series roller bearing. There is, however, ample space axially to accommodate two light series bearings mounted as a pair, if that should be desired. In this case the bearings at the outer end are always of the one-lipped construction, while the inner bearings may be of the standard construction having a straight cylindrical outer race. Some maintenance departments prefer to use the single-lipped bearing throughout in order to reduce their inventory of spare parts. In applications where the duty is just normal the same cartridge housing can be used with only one bearing (single lipped) per end by employing a longer spacing sleeve.

The "new style" frames, sizes EW to HW, provide greater radial space in the top half, sufficient to accommodate cartridge housings using the medium series roller bearings, as shown in Figure 6. This design is also typical of the AW, BW, CW and DW sizes in either the old or new style. The radial space in the top half of the IW is an exception, however, as it has not been increased correspondingly. Therefore, Figure 6 represents the only design available for this size. When considering a changeover for any of the sizes from EW to HW inclusive, it must therefore first be determined whether the frame under consideration is of the old or new style.

There are two typical designs for the General Electric MD-100 series motors, sizes MD-101 to MD-104½ being illustrated in Figure 8. For sizes MD-101, MD-102, and MD-103 it is necessary to remove some metal from the inside faces of both bearing supports to obtain sufficient axial space for the body of the cartridge housing. On the MD-104 and MD-104½ sizes metal need only be removed from the inner support, but in these sizes it is also necessary to machine a small arc at

Figure 13—Sketch showing outstanding features of cartridge type ball bearing.

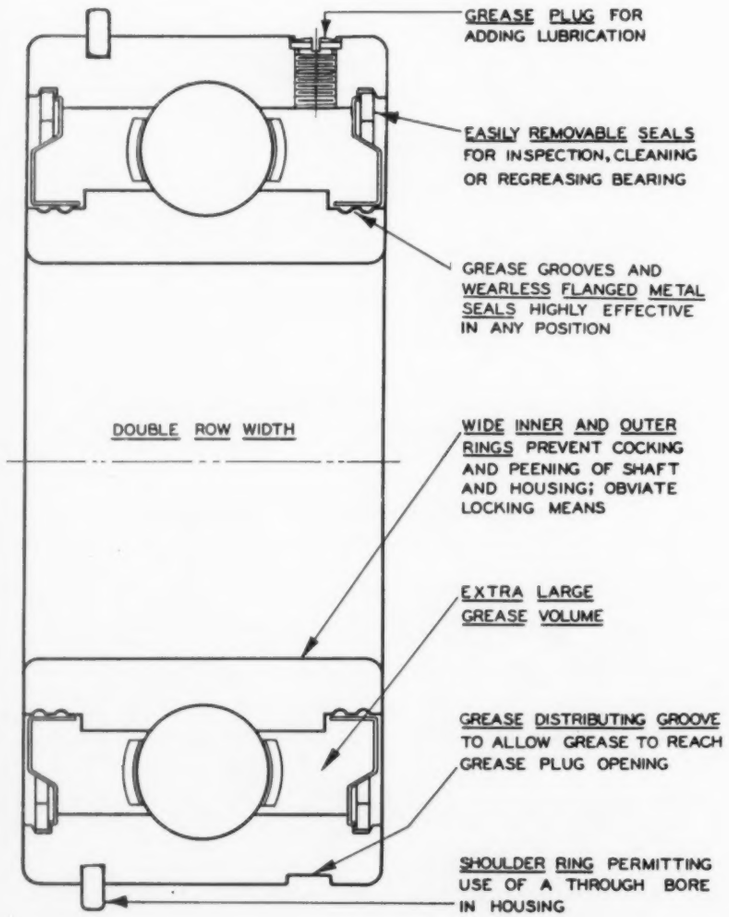
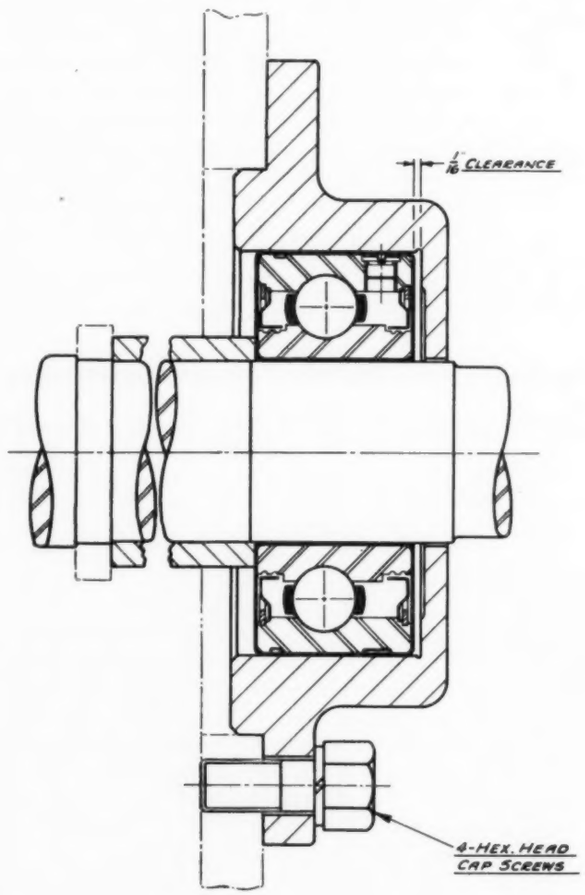

GREASE PLUG FOR ADDING LUBRICATION
EASILY REMOVABLE SEALS FOR INSPECTION, CLEANING OR REGREASING BEARING
GREASE GROOVES AND WEARLESS FLANGED METAL SEALS HIGHLY EFFECTIVE IN ANY POSITION
DOUBLE ROW WIDTH
WIDE INNER AND OUTER RINGS PREVENT COCKING AND PEENING OF SHAFT AND HOUSING; OBVIATE LOCKING MEANS
EXTRA LARGE GREASE VOLUME
GREASE DISTRIBUTING GROOVE TO ALLOW GREASE TO REACH GREASE PLUG OPENING
SHOULDER RING PERMITTING USE OF A THROUGH BORE IN HOUSING

Figure 14—Changeover design for cartridge bearing flange unit for general purpose motors.



each side along the split in the frame for a distance equal to the width of the body of the cartridge housing.

While the machine work on these four smallest sizes of MD-100 series motors is comparatively greater than on any of the six larger sizes, still it is relatively easy and simple machining. The exterior shape of the frame in each of these sizes (except the very small amount noted above for the MD-104 and MD-104½ sizes) permits of ample radial clearance all around the major diameter of the body of the cartridge housing, and the actual machine work required consists only of facing the two bearing supports to the proper diameter.

For the six larger sizes, a typical design of which is shown in Figure 9, practically all of the work can be done by burning. In all of these sizes it is necessary to remove the major part of both of the oil deflecting ribs in the top half of the frame. As these rib sections are relatively thin at the line of burning they can readily be burned out without too much danger of warpage. Of course, it is essential that the man doing this job be well-versed in this type of work. No metal is removed from either of the bearing supports, but it is necessary to form a smooth surface along the thin section where the oil deflector has been burned away from the outer rib. This is easily done by chipping or grinding.

On the lower frames there is practically nothing that has to be done on sizes MD-106, MD-109, MD-109½, and MD-110, with the possible exception of a little chipping for proper clearances. On the MD-105 and MD-108 sizes a very small ridge of the metal must be removed from each side, but on the MD-107 size a section roughly approximating a triangle ⅞ in. x 3 in. is removed from each side. The design in Figure 9 shows this clearly, this being the greatest amount of metal removal required on any of the six larger sizes.

The typical design for the Westinghouse MC and MT series is shown in Figure 10. The construction of these motor frames is such that there is relatively little space between the two bearing supports. This makes it necessary that metal be removed from the faces of both supporting ribs, and also along an arc at both sides of the top half. (Several methods of removing this metal will be discussed separately in a later paragraph.) For the MT-5 motor an additional design has been employed as illustrated in Figure 11. In this arrangement two of the light series roller bearings are used at each end, and due to the smaller outside diameter a considerable saving is effected, not only in the cost of the cartridge housings but also in the cost of the bearings. Actually, however, somewhat more machine work is required with this design, as the inner bearing support has to be bored out to a size large enough to take the outside diameter of the body of the cartridge housing. As this has to be an accurately finished bore, all of the work should be done preferably on a horizontal boring mill or else on a large lathe. Should this machine work be impossible, the design similar to the other sizes (Figure 10) can be used, or if this is likewise not possible, a design using only one of the light series roller bearings can be furnished. This, of course, permits the use of a much narrower body for the cartridge housing and requires only a very minimum of metal removal in the frame.

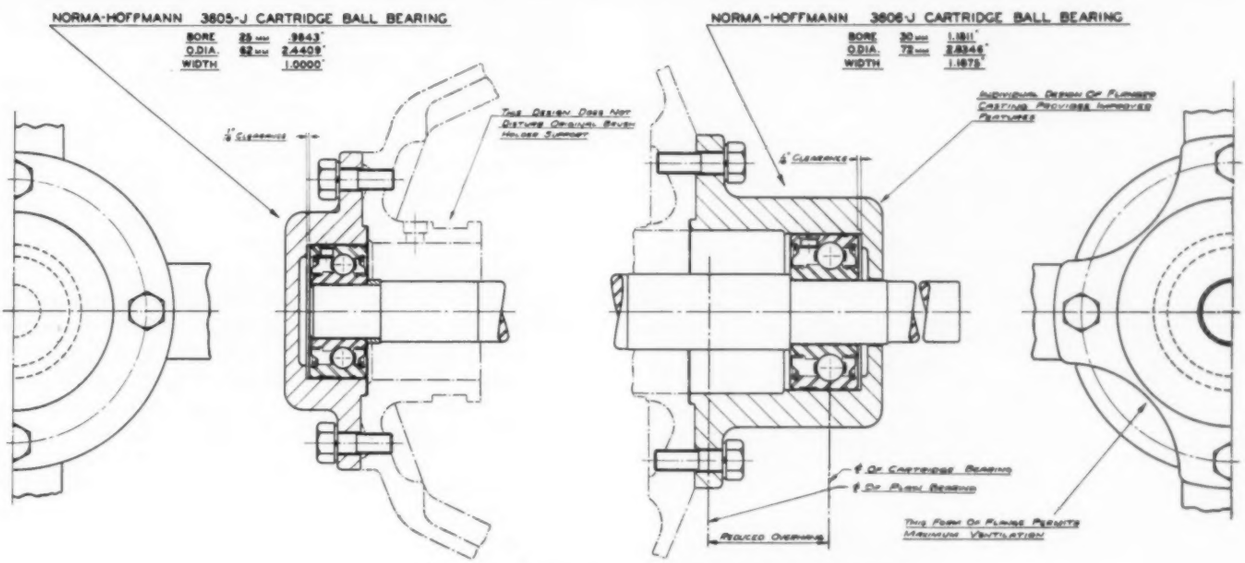
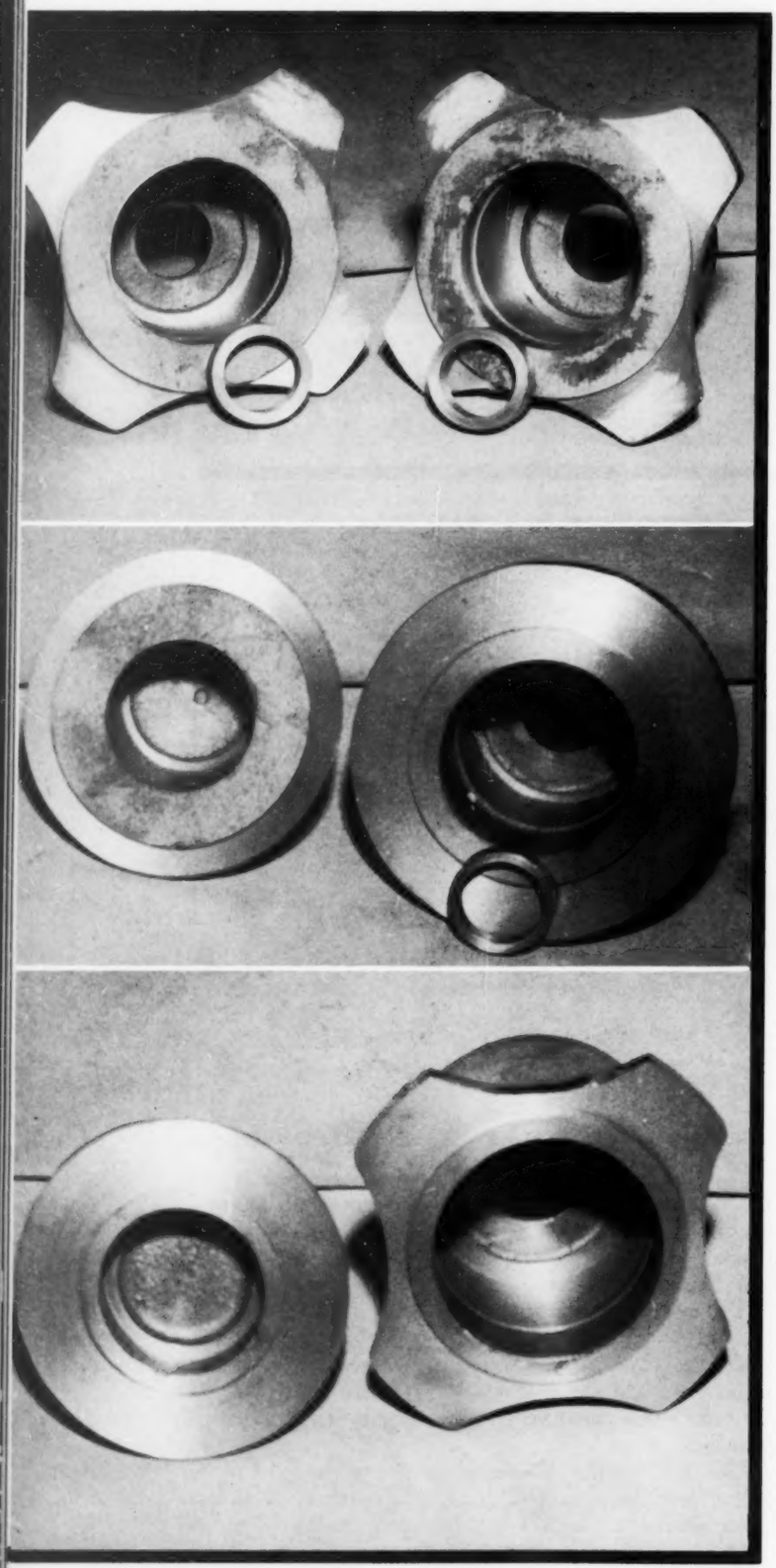

NORMA-HOFFMANN 3805-J CARTRIDGE BALL BEARING
BORE 25 mm .9843"
O.DIA. 62 mm 2.4409"
WIDTH 1.0000"
NORMA-HOFFMANN 3806-J CARTRIDGE BALL BEARING
BORE 30 mm 1.1811"
O.DIA. 72 mm 2.8346"
WIDTH 1.1378"
⅛" CLEARANCE
THIS DESIGN DOES NOT DISTURB ORIGINAL BEVEL HOUSING SUPPORT
INDIVIDUAL DESIGN OF FLANGED CASTING PROVIDES IMPROVED FEATURES
⅛" CLEARANCE
⅛ OF CARTRIDGE BEARING
⅛ OF PLAIN BEARING
REDUCED OVERHANG
THIS FORM OF FLANGE PERMITS MAXIMUM VENTILATION

Figure 15—Changeover for General Electric RC-6 motors.

While it was pointed out previously that one of the MT-5 designs did not permit the use of the old sleeve bearing shells directly (Figure 11), the same sleeve bearing armature, however, can be used by providing an extra set of shells which have been designed to fit into the space occupied by the roller bearing cartridge housings.

The MT-6 design also employs two of the light series roller bearings mounted in pairs at each end, and is quite similar to the MT-5. However, due to the existence of considerably more space between the two bear-

Figure 16—Various combinations of flange shapes are available, none of which changes the original ventilation area.



ing supports, this cartridge housing is supported on the two hubs, and in this respect it closely resembles Figure 7. Here again a design can be employed using only one of the light series roller bearings at each end, should the actual load-life requirements be within the capacity of a single bearing.

To remove the necessary metal on the two supporting ribs so as to provide the necessary axial space for the body of the cartridge housing, two methods have been used quite successfully. The first, of course, is to remove this metal, preferably by machining in a horizontal boring mill or in a lathe of the proper size. While this method is certainly the most accurate and positive, still it takes more time, and in addition, some of the electrical repair shops may not have access to the necessary machine tools at a time when they need them the most. These conditions have promoted the use of burning out the necessary amount of metal and dressing up the face, where the cartridge housing thrusts, with a portable grinder. The only drawback to this procedure is the possibility that sufficient warpage or distortion might occur to throw the roller bearing cartridge housing out of proper alignment. Frankly, we feel that this possibility is rather remote, based upon reports that no perceptible distortion developed on a number of jobs which were handled throughout by burning, even though the old bores were not welded up and remachined.

There is one situation, however, in which burning undoubtedly is the proper procedure. In a great majority of these older motors the bore in the bearing supports has been worn considerably oversize so that it becomes necessary to weld up this surface and rebore to the correct dimension. In this case there is, of course, no question at all about burning out the required amount of metal from the two bearing supports. This burning is done either before or after the bore is welded up, but definitely before the bore is remachined. Therefore, if any warpage should have occurred, the newly machined bore will again be concentric and definitely in line for all four of the bearing supports, eliminating any possibility of out-of-alignment of the two roller bearing cartridge housings. This appears to be the ideal method of procedure, as it definitely guarantees correct alignment, as well as the proper clamp fit of the cartridge housings in the frame. Furthermore, it is the least costly.

In the past few years there has been an insistent demand from certain maintenance departments for a changeover unit for Westinghouse MT and MC series motors, which unit could be mounted directly in the space occupied by the sleeve bearing shell. This demand was occasioned by the fact (as pointed out above) that these frames have to be returned to the shop for a considerable amount of metal removal when using the standard changeover, incorporating the medium series roller bearings.

A design was finally provided in the fall of 1939 which permitted strict interchangeability without any machine work whatever on the motor frames. In fact, the roller bearing shaft diameters were practically identical with the sleeve bearing shafts, the only exception being the tolerance on the diameter. Since this tolerance is only the addition of an average of .0005 in. on the diameter, it means that the roller bearing shafts can also be used

Figure 17—Mountings of cartridge bearing flange units to motor brackets.

directly in the old sleeve bearing shells, should that ever become necessary.

Naturally, with the greatly reduced space limitations the bearing capacities are considerably less, and therefore a much shorter life must result. Although this type of changeover has since been used on crane bridge drives, trolleys, and hoists, there have been no bearing failures to date. Frankly, we are greatly pleased with these results, although we still feel that the capacity may be inadequate for certain requirements. Figure 12 is typical of this design and shows the actual construction of one of the MT changeovers. This construction is only applicable to the Westinghouse MT and MC series, as they are the only ones with sufficient space between the shaft diameter and the bore in the frame to accommodate the outside diameters of the bearings used.

However, when it is considered that practically no machine work is required on the Crocker-Wheeler frames, and that the necessary work on the General Electric MD-105 to MD-110 frames can practically be done in the field with a cutting torch and hand grinder (assuming, of course, that the bores in the frame are up to standard), the use of this latest development for the Westinghouse frames tends to balance the general machining requirements on all of the frames to a greater extent than before.

GENERAL PURPOSE MOTORS

Now we come to the most recent development in motor changeovers. This is the application of Norma-Hoffmann cartridge ball bearings to general purpose motors, d-c. as well as a-c.

In the past it has been practically impossible to provide a changeover for these motors because of space limitations. The only way to apply ball bearings to these particular motors was to purchase complete new brackets for both ends with the necessary bearings, etc. Frequently a new shaft was also required. This is a rather costly procedure and it has been natural that changeovers had not been applied to these motors, except in rare cases.

However, the development of the cartridge bearing flange unit has changed this entire picture. We have definite data showing that the cost has been reduced tremendously. For example, in the case of a 5 hp., 1200 rpm. motor, the cost to the customer was reduced to less than one-third.

To show how this is possible it is first necessary to consider this bearing itself, which is shown in cross-section in Figure 13. It is essentially a single row ball bearing with the races made to the American standard double row width. The bearing is a self-contained unit equipped with easily removable metal seals on both sides and with a grease distributing groove and grease-plug in the outer ring for adding lubricant as it may be needed.

The bearing is fully lubricated at our factory with a special long-life grease which we prepare ourselves. The double row width definitely permits filling the bearing with sufficient grease for long service. The seals are exceptionally effective in keeping out dirt and retaining the grease. In fact, these seals will actually retain the grease when operating in a vertical position. These bearings provide a completely protected unit at each end of the shaft and only need a support of some kind to position them properly. This is readily accomplished by means of an inexpensive flange unit similar to the typical design shown in Figure 14.

To adapt these bearing flange units to the present brackets it is merely necessary to remove the hub on the bracket by sawing, burning, or turning, then facing and counterboring for a rabbet fit, followed by boring through for clearance over the outside diameter of the bearing selected. Four drilled and tapped holes, generally in the arms of the brackets, provide the means of securely anchoring the flange unit to the bracket itself.

In general, the shaft is machined back for a short distance on either end for a bearing seat. In cases where

Figure 18—Installation of cartridge bearing flange unit changeover.

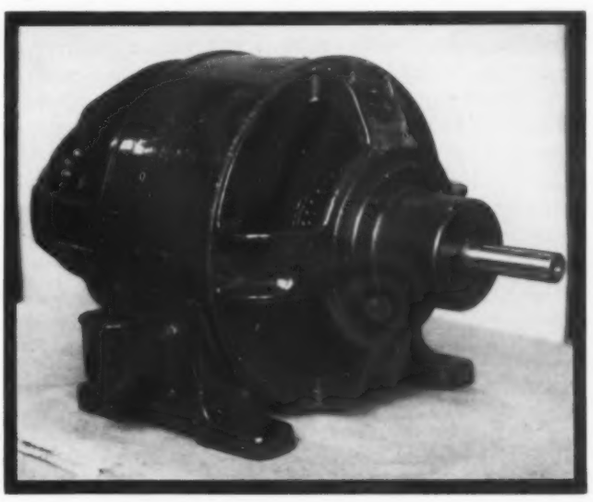


Figure 19—Commutator end of motor with cartridge bearing flange unit.

the remaining shaft shoulder is insufficient for a proper bearing shoulder a collar is provided. There are some applications, however, where a spacing sleeve of several inches in length is necessary due to design requirements.

This same general design is also used for the crane motors previously discussed, for in many cases the capacity of the ball bearing is more than sufficient for the requirements. We would point out here that we have had these ball bearings in service on crane trolley motors for the past two years, with no indications of distress.

One of the outstanding features of the design shown in Figure 14 is the fact that it can be applied to the commutator end of those older d-c. motors in which the brush holder rigging is mounted on a relatively small diameter hub on the inside of the bracket. The importance of this feature can readily be appreciated from the details shown in Figure 15. The wall thickness of the inner hub must be maintained at a certain minimum amount, which naturally determines the maximum outside diameter of bearing that can be used. We have found these proportions to work out very effectively as shown, but as can be seen, there would be no clearance for an inside cap or standard cartridge housing arrangement, should the standard type of ball bearing be considered. The fact that our cartridge bearing has the enclosures built within itself makes it possible to apply such a ball bearing mounting within the confined space limitations.

Of primary importance is the fact that the inner race of the bearing has a shrink or press fit on the shaft, thereby maintaining maximum bearing capacity and eliminating any possibility of scoring the shaft, which in turn may cause shaft breakage. This detail should not be overlooked—the inner race of a ball bearing is conceded to be the most highly stressed member, and if it is not backed up properly with a shrink or press fit on the shaft, fatigue failure will positively develop in a much shorter period of time than when it is properly backed up. The extra width of the cartridge bearing also provides more firm seating on the shaft. Referring now to the pinion end mounting, there are several outstanding advantages. The actual length of the casting is made to correspond with the original length of the bracket hub. This permits mounting the bearing closer to the center line of the load, thereby reducing overhand, and in many cases actually increasing the stiffness or strength of the shaft extension.

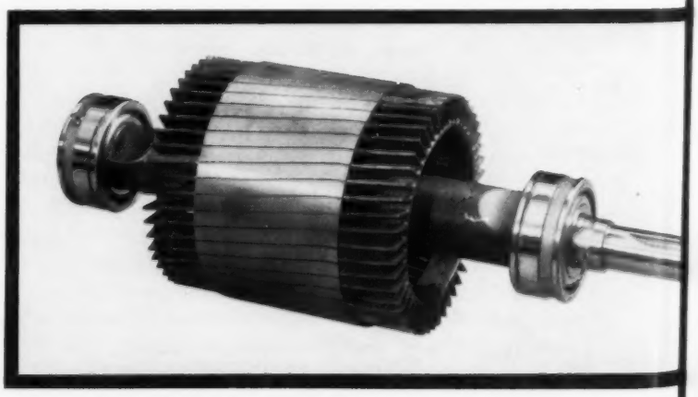
As these castings are all individually designed for the particular motor involved, it is possible to leave out sections of the flange which would interfere with the proper ventilation of the motor. All of our designs provide the same ventilation area as the original brackets. Some of the various combinations of flange shapes are shown in the combination of photographs, Figure 16.

Assembly and disassembly of the motor is a very simple matter as it is only necessary to slide the brackets over the bearings after the armature is located in the frame, and afterwards tighten the bracket cap screws. Figure 17 is a photograph of a set of d-c. motor brackets just changed over and ready for mounting and painting, while Figure 18 and Figure 19 show the completely changed over motor, from the pulley end and commutator end respectively.

Should one of the cartridge ball bearings have to be replaced, the procedure is very easy as it simply follows the same general practice as used for later motors originally equipped with ball bearings. A decided advantage, however, is the fact that it is only necessary to pull the bracket off the bearing without the need of removing any accessory pieces, such as caps, seals, or separate cartridge housings. The bearing itself contains all of these elements, and the bracket merely functions as a locating medium. An armature equipped with these bearings is shown in Figure 20, and can be mounted in racks with no further protection, without fear of getting dirt into the bearings.

This is one of the outstanding features of this bearing. At no time (as long as the seals are not removed) is there the possibility of dirt or grit getting into this bearing during assembly, as is the case with any standard or unsealed bearing. As every maintenance

Figure 20—This armature is equipped with cartridge ball bearings.



man knows, his primary causes of bearing failure have been due to dirt getting into the bearing, in some way or other, and the lack of proper lubrication. The bearing is not only effectively sealed against accidental entrance of dirt at any time, but being fully lubricated at the factory with our special long-life grease, eliminates any possibility of failure during normal operation due to lack of or improper grease.

As a general resume, it appears desirable to include a list of the advantages derived from the changeovers previously discussed. These are as follows:

1. Lower maintenance and better performance.
2. No oil soaked windings, therefore fewer armature rewind jobs.
3. No oil on commutators, hence longer commutator and carbon brush life and better motor operation.
4. Increased bearing life, thereby reducing bearing replacement cost and labor.
5. Fewer "out of service" hours for the motor.
6. Reduced greasing or oiling schedules; in many cases regreasing is done only when armature is sent to the shop for other repairs.
7. Saving on labor to grease and oil bearings.
8. Reduced lubricant cost.

   NOTE: The following points apply to all of our motor changeovers in general, but more especially to the cartridge bearing flange units.
9. Changeovers can be made to present brackets at very low cost. (There are possibly a few exceptions in which the present brackets cannot be employed.)
10. These bearings have very effective seals which prevent dirt entering the bearing, thereby giving longest life possible.
11. Same seal retains grease efficiently.
12. Center line of bearing is brought closer to load, thereby strengthening shaft.
13. Machine work to apply changeover is very simple and can readily be done in any shop.
14. The bearing has a large grease capacity—properly packed at the factory with our special long life grease—and need not be regreased for a long period of time. (In fact many of the mills and mines have eliminated greasing the bearings on the job altogether.)
15. No dirt gets into the bearing during assembly, thereby eliminating one large cause for bearing wear.
16. The bearing has means for regreasing should this be necessary for special jobs.
17. This type of changeover does not reduce ventilation area, as all of the units are tailor-made for each individual job.
18. Bearings are given a tight fit on the shaft, thereby assuring the greatest life of the bearing and no scoring of the shaft.
19. No lock nuts or lock washers required, thereby maintaining shaft strength at maximum.
20. Special greases are available for abnormal jobs, such as operation under extremes of temperature, or in the presence of water vapor, etc.
21. Provides an attractive design individually adapted to each motor.

A. I. S. E. *District Section Activities*

CLEVELAND-YOUNGSTOWN

JANUARY 19-20, 1942

"Plate Mills and Strip Mills in the Defense Program," by Joseph Malborn, United Engineering and Foundry Company, Pittsburgh, Pennsylvania

DETROIT—JANUARY 13, 1942

"Analysis of Power Requirements for Dry Blast," by R. V. D. Dunne, Carrier Corporation, Syracuse, New York

PHILADELPHIA—JANUARY 3, 1942

Symposium: "Recent Developments in Control," by H. H. Angel, Electrical Department, Bethlehem Steel Company, Sparrows Point, Maryland; E. H. Alexander, Industrial Department, General Electric Company, Schenectady, New York; J. R. Erbe, Industry Engineering Department, Westinghouse Electric and Manufacturing Company, Pittsburgh, Pennsylvania

PITTSBURGH—JANUARY 12, 1942

Symposium: "Trends in Low-Voltage Control and Switchgear," by W. B. Snyder, Industrial Engineering Department, General Electric Company, Schenectady, New York; L. L. Fountain, Switchgear Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania; F. A. Wright, Cutler-Hammer, Inc., Milwaukee, Wisconsin; Harry Wilcox, Electric Controller and Manufacturing Company, Cleveland, Ohio

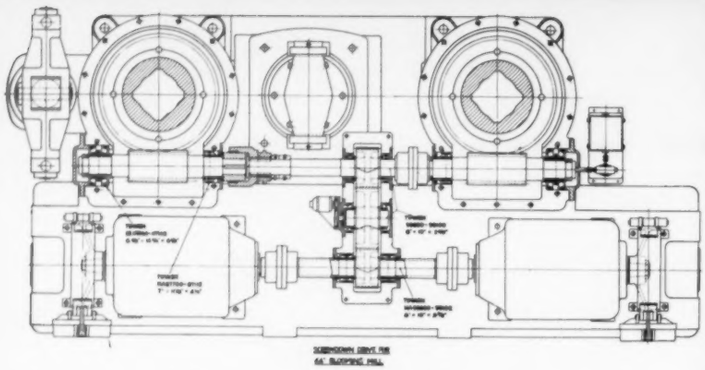


Figure 1

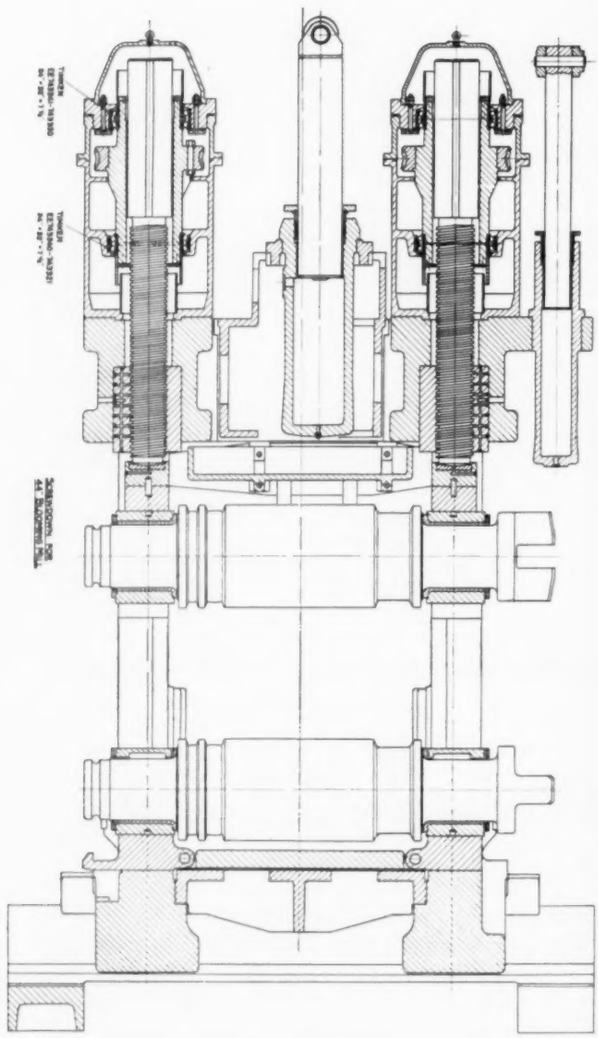
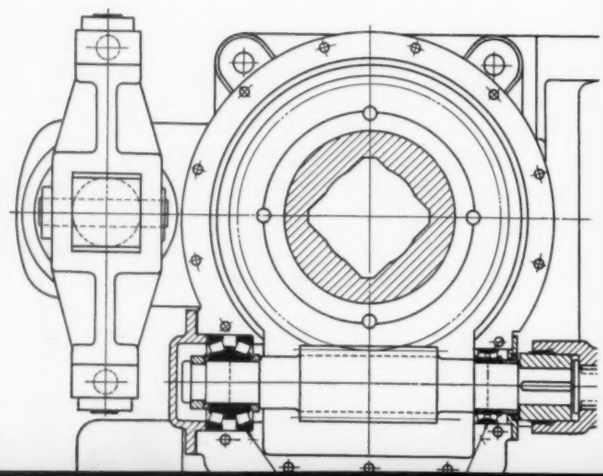


Figure 2

▲

Figure 3



APPLICATION of BEARINGS

By S. M. Weckstein

Chief Engineer

TIMKEN ROLLER BEARING CO.

Canton, Ohio

▲ THE demand made on mill auxiliaries that they respond to all variations of speed and load which may be encountered in the rolling mills and do so with a minimum of maintenance has dictated the use of anti-friction bearings in this equipment.

Mill screwdowns are called upon to respond quickly to changes in roll setting. Tapered roller bearings are used to handle the large thrust loads as well as the radial loads which are encountered. A general arrangement of the bearings on a screwdown drive for a blooming mill is shown in Figure 1.

Two motors are connected to a herringbone gear reduction unit which in turn is connected to two worm shafts which drive the worm wheels on the mill screws. The input shaft of the herringbone reduction unit is mounted on two row tapered roller bearings which are permitted to float and find themselves with reference to the motors and the gear mesh. The intermediate gear and the output shaft are mounted on single row bearings which are fixed in the gear case. Shims are used to obtain the bearing set-up and proper gear mesh. The worm shafts use two row steep angle tapered roller bearings at one end. These bearings are fixed in the worm housing and carry the thrust load in either direction. The two row bearings at the opposite end of the worm shaft float in the housing and carry radial load only.

The mountings of the bearings on the worm wheel are shown in Figure 2. The worm wheel is mounted on a sleeve which is carried on two row tapered roller bearings in the top and bottom positions. In this particular layout, the top and bottom bearings are of the same size but are arranged differently to simplify the design. The top bearing, which is a two row cup adjusted bearing, is fixed in the housing and carries the weight of the sleeve and parts mounted on it. The lower bearing, which is of the two row cone adjusted type, floats in the housing and carries radial load only. Both bearings are assembled on the sleeve and the entire assembly is entered into the main housing. The setting of the worm wheel is obtained by means of shims used between the flange on the housing of the upper bearing and the main housing itself. The same lubricant which is used to lubricate the worm and wheel is also used to lubricate the bearings.

ANTI-FRICTION *in Mill Auxiliaries*

Presented before A. I. S. E.
PITTSBURGH DISTRICT SECTION

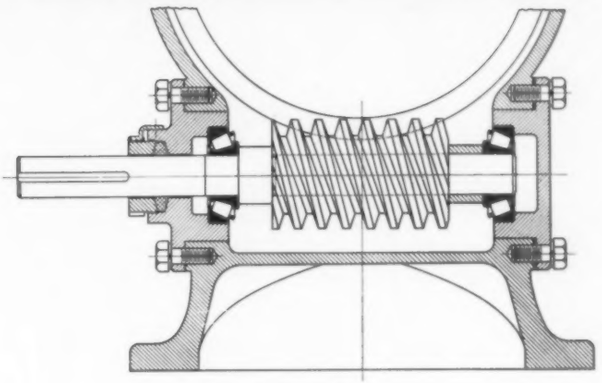


Figure 4

The mounting of the bearings on the worm shaft of the screwdown may differ from that shown in Figure 1 or Figure 3. In this later figure the thrust bearing is mounted directly in the housing. Where it is desired to provide for change in location of the center of the worm, the bearings may be mounted in a carrier which is fitted in the housing and adjusted endwise by means of shims between the housing and a flange on the carrier. In some cases, a design similar to that shown in Figure 3 is used except that a washer ground to a specified thickness is used between the shoulder in the housing and the inner cup. These features are especially important where cone type worms are used.

On some of the smaller size mills, the screwdown worm shafts are mounted on single row bearings. In this design as illustrated in Figure 4 a single row steep angle bearing is used at each end of the worm shaft. The bearings are adjusted by means of shims as shown. In the case of cone type worms, shims should be used at each bearing and these shims may be shifted from one side to the other to obtain the desired worm setting.

In Figure 1 a typical herringbone gear design was shown. Figures 5 and 6 show additional designs, variations of which have been successfully used in different installations.

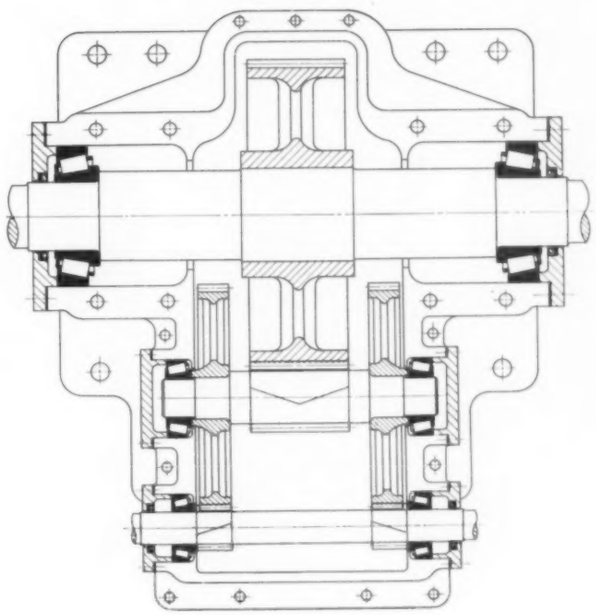


Figure 5

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Figure 6

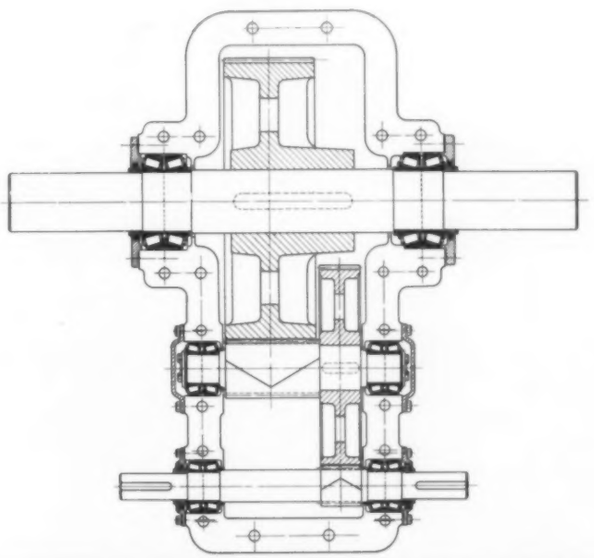


Figure 5 shows a double reduction herringbone gear unit using single row bearings on each gear shaft. To obtain proper bearing adjustment and gear mesh, shims are used at each bearing. These shims may be shifted from one end to the other to obtain the desired results.

Figure 6 shows an alternate double reduction herringbone gear unit in which all shafts are mounted on double row tapered roller bearings. In this design all the bearings float with the exception of one bearing on the output shaft. This bearing is fixed in the housing and carries any thrust which may be set up from the gears. It will be noted in this design that the lower half of the case is built in such manner that a level of oil is always maintained around the bearings. The bearings are lubricated with the same oil which is used on the gears. The oil to the bearings is introduced through the groove and holes in the double outer race. The excess oil overflows into the case.

Vertical edging mills present a problem of proper pass location, thrust loads and bearing lubrication. All of

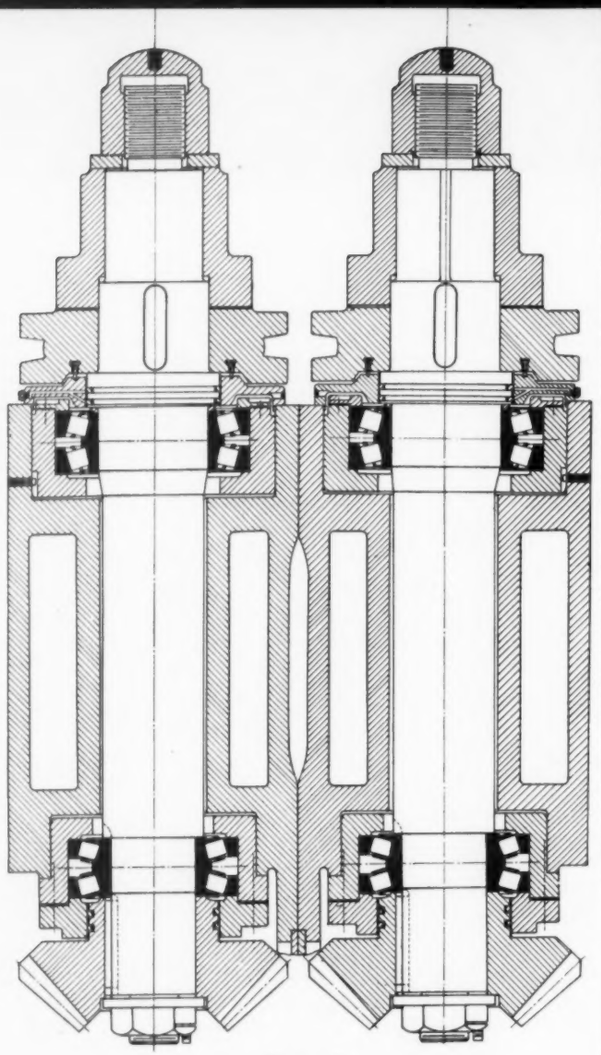


Figure 7

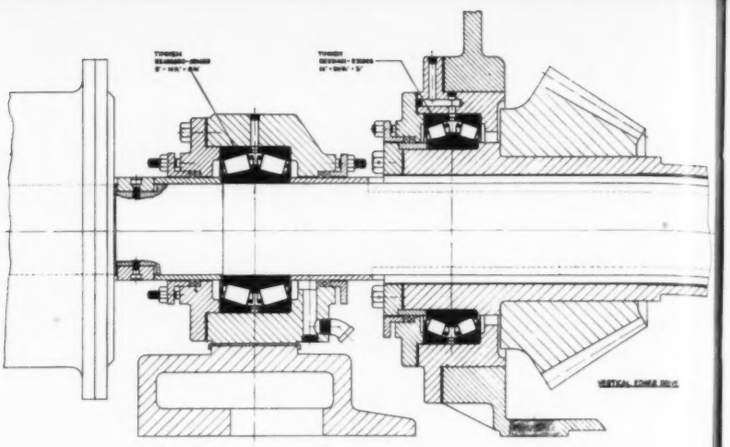


Figure 8

these points are readily handled by the use of tapered roller bearings.

A typical design of a vertical edging mill is shown in Figure 7. A double bearing is used adjacent to the edging roll. This bearing is mounted in a cartridge which floats in the housing. At the bottom of the roll spindle another double bearing is mounted in a cartridge which is bolted to the housing. These lower bearings position the main rolls and the bevel gears and also carry all the thrust loads from the gear and roll. Piston ring closures are used at the bottom bearings. At the top bearings, the closure is made more positive. In addition to the piston rings, a wiping closure is provided. This is accomplished by machining a groove in the edging rolls and filling this groove with a suitable packing. The upper closure is provided with circular extension which engages the packing and forms a dam against the entrance of scale and water. A circulating oil system is used for the upper and lower bearings.

The arrangement for the drive for the vertical edgers is shown in Figure 8. The drive comes in through the coupling at the left hand end of the shaft which is

▲

Figure 9

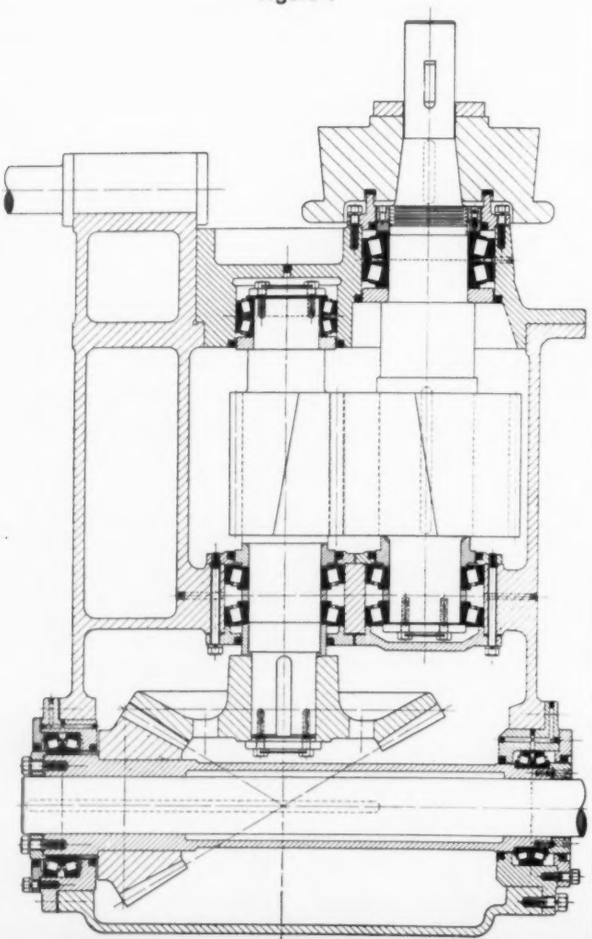
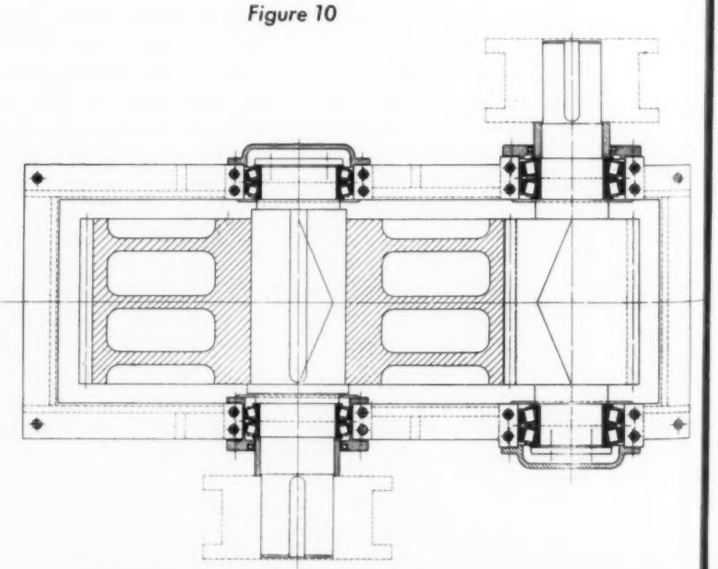


Figure 10



supported by a two row tapered roller bearing as shown. At the opposite end of this shaft, a cylindrical roller bearing is used. On this shaft is located a splined sleeve which carries the bevel pinions which mesh with the bevel gears on the vertical edging rolls. Arrangement is made to move the sleeve along the shaft for the proper setting of the edging rolls.

Another design of edging mill rolls and drive is shown in Figure 9. Here again the drive is through bevel gears. There is an additional reduction from the bevel gear shaft to the edging rolls. The closure used at the upper edging roll bearing is similar to that described in Figure 7. It should be noted, however, that in this design the lubrication of the bearings is separate from that of the gears. Each bearing is completely enclosed and may be grease lubricated. On each shaft and on the horizontal sleeve, one bearing is fixed and the opposite bearing is permitted to float.

The use of anti-friction bearings on manipulators and turn tables is limited primarily to the gear reducers which are used to drive these units. This is due to the act that quite a number of the movements or motion of the parts is of an oscillating nature and also due to the fact that the speeds on some of the rotating parts are extremely low. A typical single reduction herringbone gear drive is shown in Figure 10. Double row tapered roller bearings are used in all positions. All bearings float except the bearing adjacent to the coupling on the low speed shaft, which is fixed in the housing. A circulating oil system is used on both the gears and bearings. The oil is led to the holes in the center of the outer race of the bearings and from there flows to both sides of the bearing. By means of dams welded to the lower half of the case an oil level is maintained around the bearings. The excess oil overflows the dams and is returned to the circulating system. In this way the bearings are assured of a supply of oil even if the unit should be started before the circulating system is turned on or in case of a failure of the oiling system.

Guides of various types have been equipped with tapered roller bearings. Figure 11 shows the design used on a rod mill twist delivery guide. The bearings are mounted directly in the guide roll. The outer races are pressed into the roll while the inner races are mounted with a sliding fit on the stationary pin which is located in the supports. The bearings are grease lubricated through a hole in the pin. Annular groove closures and labyrinth flingers are used to enclose the bearings. This design of closure was selected in order to keep friction down to a minimum.

A similar design is used on rod mill entry guides as shown in Figure 12. The bearings are mounted in the same way as in Figure 11. An alternate closure design is shown. It will be noted that the bearings are mounted on an eccentric pin. This arrangement provides a simple means of adjusting the roller guides to the desired position.

An alternate design of roller entry guide is shown in Figure 13. Here the roll is pressed on the shaft and the bearings are mounted at each end of the shaft. The bearings are enclosed in the supporting framework and are individually lubricated. This design is used primarily on smaller rolls where the bearings cannot be mounted directly in the roll.

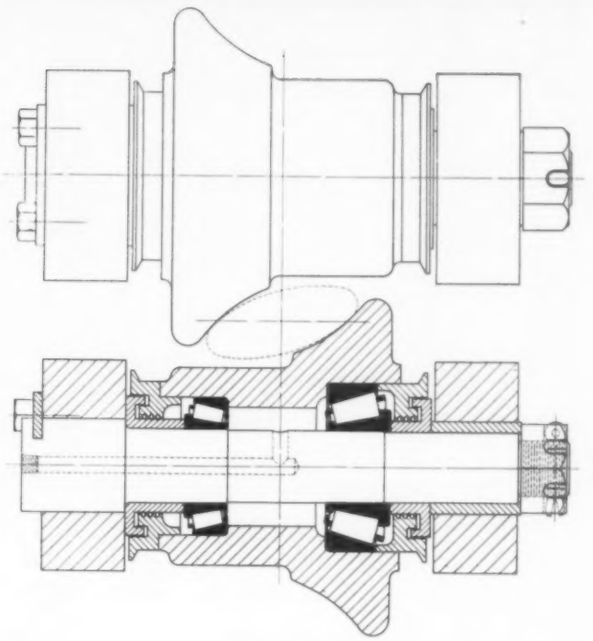


Figure 11

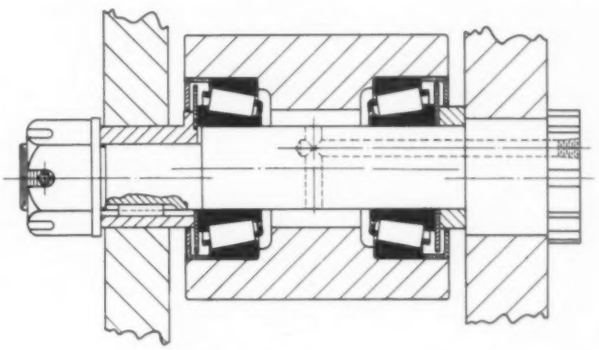


Figure 12

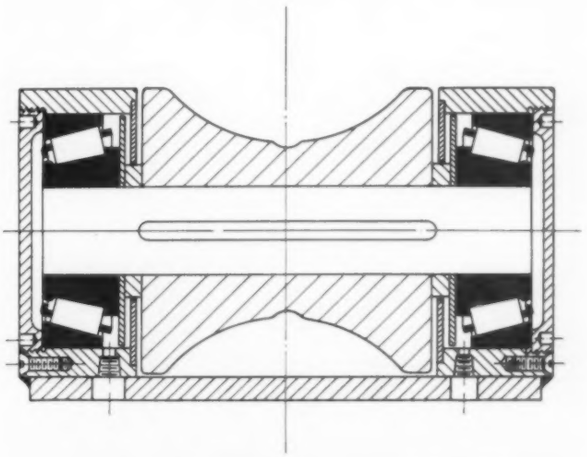


Figure 13

APPLICATION and MAINTENANCE of BEARINGS in Rolling Stock and Cranes

By A. S. Murray

Steel Mill Engineer

SKF INDUSTRIES INC., Philadelphia, Pa.

Presented before the A. I. S. E.
PITTSBURGH DISTRICT SECTION

▲ THERE are a number of different possible approaches to the subject "Application and Maintenance of Bearings in Rolling Stock and Cranes." The subject presumes that theoretically premature bearing replacements are required due to the existence of improper conditions and need for improved designs. There have been developed basic designs that utilize the various types of bearings in reasonably effective mountings for the respective applications. This does not mean that there cannot be a large improvement in the actually delivered bearing performance. The present designs can give a higher and more uniform level of anti-friction bearing satisfaction through more conscientious adherence to and recognition of fundamentals.

The discussion will consider types of bearing failures analysed with reference to the fundamentals involved in an effort to make:

1. Designers and their shops and maintenance departments conscious of the influence certain factors have on bearing performance.
2. Maintenance departments aware of their ability to eliminate some causes of premature bearing failure when making replacements.

The most frequent single cause for bearing replacement is fatigue. Bearing life is the function of the

LOAD CYCLE — AVERAGE LOAD CALCULATION

P = NOMINAL LOAD

		ARITHMETICAL AVG	CUBIC EXPONENTIAL AVG
		AVG LOAD = $\frac{P_1 t_1 + P_2 t_2 + P_3 t_3 + \dots}{t_1 + t_2 + t_3 + \dots} = \frac{\sum P_1 t_1}{\sum t_1}$	MEAN EFF. LOAD = $\sqrt[3]{\frac{P_1^3 t_1 + P_2^3 t_2 + P_3^3 t_3 + \dots}{t_1 + t_2 + t_3 + \dots}} = \sqrt[3]{\frac{\sum P_1^3 t_1}{\sum t_1}}$
40%P	FOR 25 TIME INTERVALS	40P × 25 = 1000P	40P³ × 25 = 0.16P³
65%P	20 " "	65P × 20 = 1300P	65P³ × 20 = 0.55P³
80%P	20 " "	80P × 20 = 1600P	80P³ × 20 = 1.02P³
100%P	10 " "	100P × 10 = 1000P	100P³ × 10 = 1.00P³
130%P	15 " "	130P × 15 = 1950P	130P³ × 15 = 3.30P³
200%P	10 " "	200P × 10 = 2000P	200P³ × 10 = 8.00P³
	= TOTAL 100 " "	100 8850P	100 14.03P³

AVG LOAD = $\frac{8.85P}{10}$ = 0.885P = 88.5%P

MEAN EFFECTIVE LOAD = $\sqrt[3]{\frac{1403P^3}{10}}$ = 1.12P = 112%P

% ACTUAL LIFE EXPECTANCY = $\left(\frac{88.5\%P}{112\%P}\right)^3 \times 100\% = (.079) \times 100\% = 49.4\%$

Figure 1

▲

Figure 2

Figure 3

number and intensity of repeated stresses. Designers normally have a reasonably accurate picture of the hours of service for which their equipment should be designed. Unfortunately, however, there is a tendency to minimize the required bearing capacity and use an average load to permit reducing the bearing size or to substitute a lighter section bearing to decrease a shaft stress that would otherwise be too high. The shaft stress is usually checked under the maximum load, and the bearing life under the average load. This is slightly incongruous as both are subject to similar stress fatigue limitations.

However, there are justifiable reasons for using the so-called average load for checking the bearing life, provided it is determined in the proper manner. The calculation of the average load is usually the real source of error as the loads must be averaged according to an approximate cubic function and not an arithmetical average.

In order to emphasize the difference between an arithmetical average load and a properly determined average load we identify the latter by the description "mean effective load." Using an arbitrary loading cycle and loads as percentages of the nominal load, the arithmetical method gives an average load equal to 88½ per cent of the nominal load. The mean effective load is 112 per cent of the nominal load determined on the basis of the same loads and loading cycle. These calculations are shown in some detail, Figure 1. The arithmetical average load is only 79 per cent of the mean effective load. The magnitude of the difference does not indicate the true degree of its importance. Actually this difference means that the life expectancy will be less than one-half of the calculated hours based on the average load determined by the arithmetical method. It is obvious that an average load should not be used as a means to minimize the load conditions and justify the selection of a smaller bearing. Anti-friction bearings do not have magical powers, and regardless of juggled calculations will only give life commensurate with capacity and the loads to be carried.

The initial stage of fatigue is characterized by incipient flaking. This condition in an outer race appears as shown in Figure 2. An attempt at illustrating fatigue is shown in Figure 3. So small a fatigued area would have no detrimental effect on the performance of equipment such as we are discussing. However, the spalling spreads due to abnormal stress concentration and develops into conditions shown in Figure 4.

Fatigue may appear after comparatively short service and the bearing may still have ample capacity to give long service under reasonable conditions. Any single factor, or combination of several factors, may be responsible for premature fatigue of the original bearing and also early failure of succeeding replacements provided only the bearings are changed.

The normal load distribution in a bearing is indicated in Figure 5. Notice the important load zone area extends for approximately 120 degrees. Opposite the load zone, clearance exists between the rolling elements and one race.

If the housing is out-of-round, the outer race may be deformed into an ellipse having a shorter axis than the diameter over the rolling elements. This condition is responsible for the appearance of the outer race in

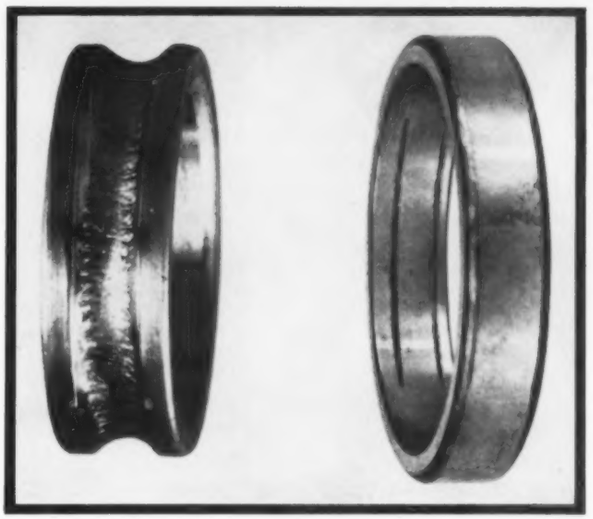
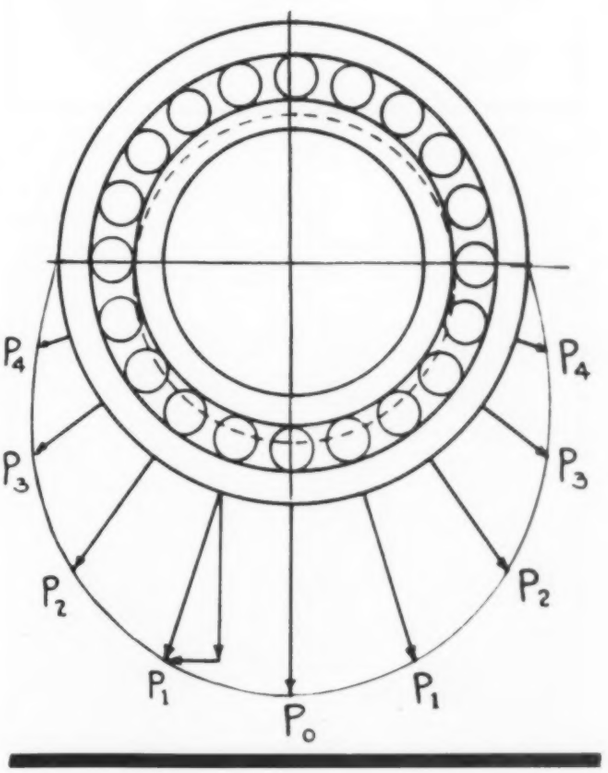


Figure 4

Figure 6. The flaking may be on diametrically opposite portions of the outer ring or may appear on only one portion and the opposite portion of the outer race will be heavily marked by rolling elements. In either case the load that the bearing has had to sustain is very much greater than calculated due to the rolling elements squeezing through the "bottle neck." The resultant bearing life bears no true relationship to its ability to do its normal job.

When the specified fit for an outer race in a housing

Figure 5



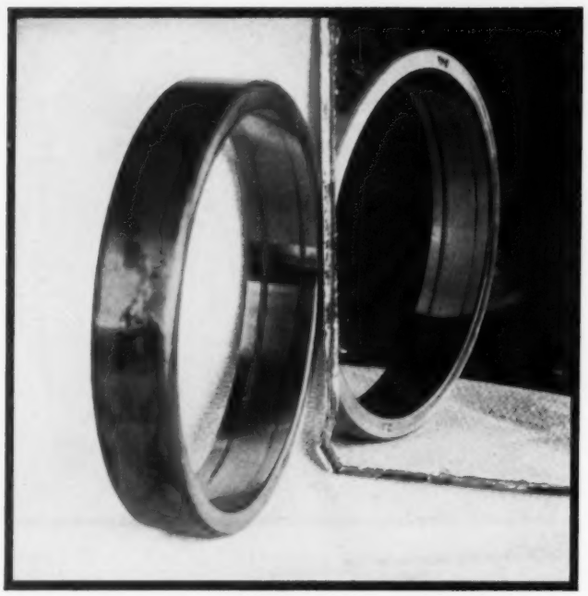


Figure 6

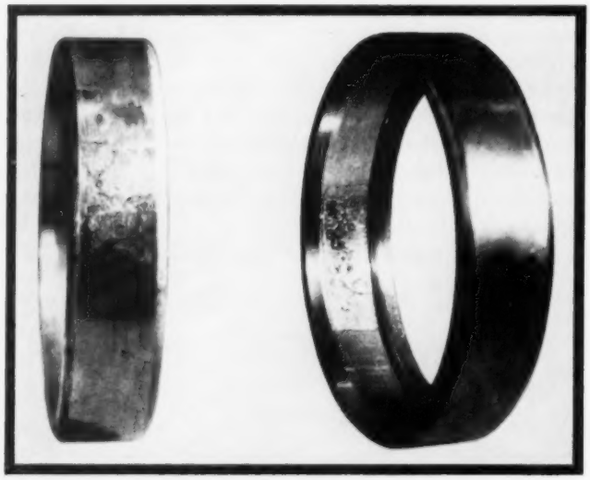
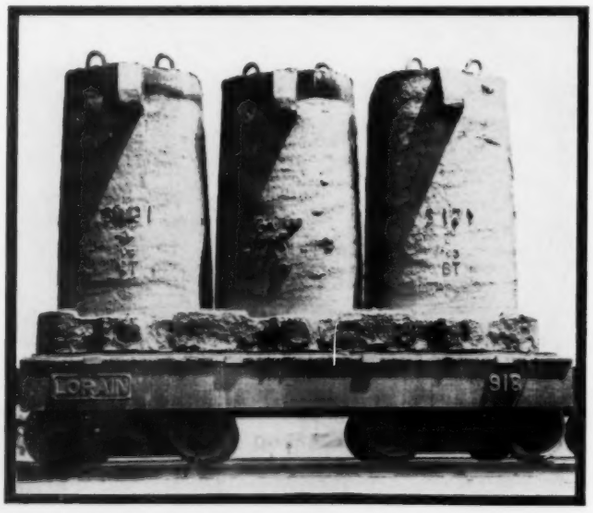


Figure 7

▲

Figure 8

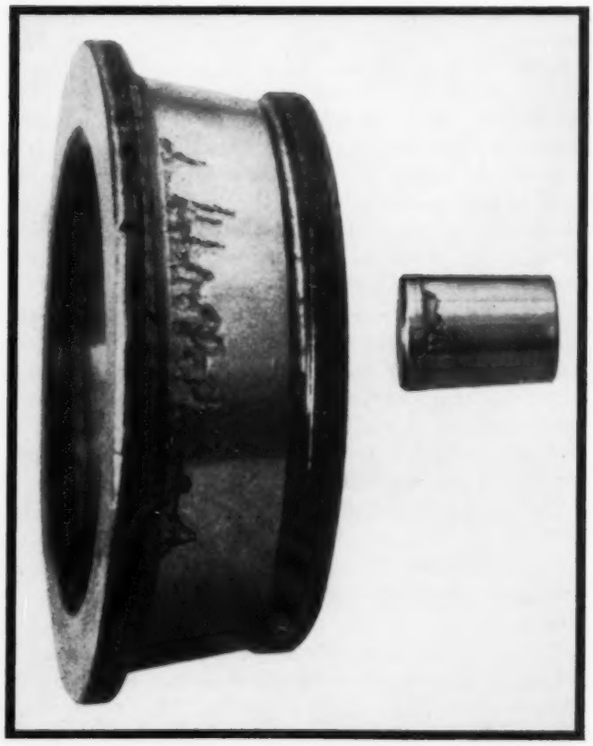


bore makes it difficult to assemble there is the temptation to take a light cut out of the housing bore and make it easy to slide the bearing into position. The example in Figure 7 is a defense for those who set such tolerances. The contact between outer race and housing bore was not intimate enough and the constant working between these loose parts caused the contact corrosion that developed on the outside diameter. The corrosion is undesirable, but it is more important as an indication of the cause for the localized fatigue that often appears on the other side of the outer race in the zone contacted by the rolling elements. This corrosion is also produced by too weak a housing that deforms under load and does not properly support the outer race.

A bearing outer race has no rigidity due to its own cross section, but takes the shape of the housing bore in which it is mounted. Deformation of the outer race in order to contact an oversize housing bore under a heavy load produces a greater radius of curvature than desired in the loaded zone of the outer race and yet the looseness in the bearing may be sufficiently great that the diameter over the rolling elements will be less than the minor axis. This condition will prevent diametrically opposite loading of the outer race, but will cause the working load to be transmitted to the outer race by a fewer number of rollers. A fewer number of rollers means a smaller arc of contact, and so we get a localized fatigue area with very short load paths in a circumferential direction on each side of the spalled area.

The preceding remarks about the damage done by out-of-round housing bores also apply similarly to inner races that are mounted on out-of-round shafts. Normally, however, seats are not as badly out-of-round as bores due to the greater ease of accurately turning shafts.

Figure 9



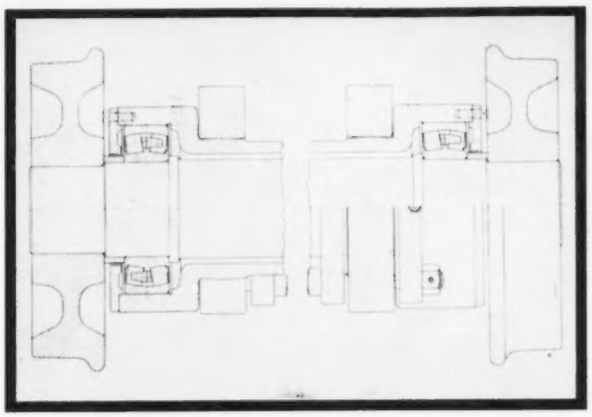


Figure 10

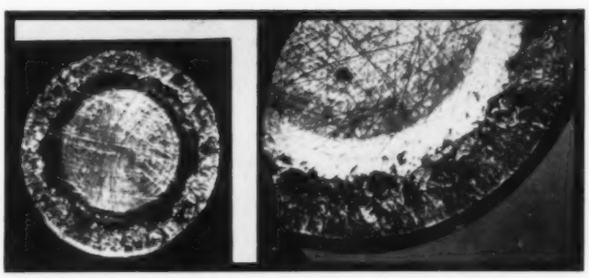


Figure 11

Figure 12

▲

Figure 13

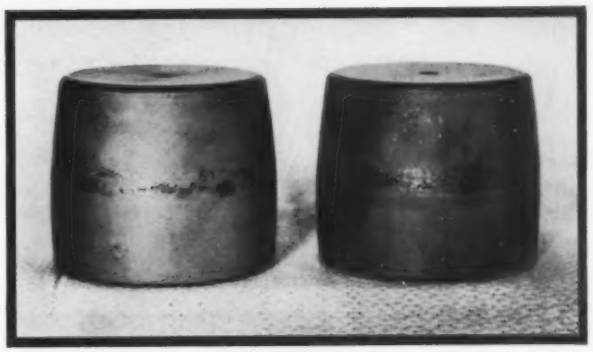


Figure 14

The weave and the distortion of machines under load has other ramifications, and in some classes of equipment make the characteristics of an individual type of bearing preferable to other types. For example (Figure 8) ingot cars and cranes often have undesirable track conditions and both at times are subject to overload. Extremely high stresses are temporarily concentrated in certain members that go through the yield point and become permanently distorted under the overload. The effect of such a change on the alignment of a machine will persist after the overload is relieved and the harmful effect continues even in the presence of a normal loading condition. Two supporting bearings no longer have a common axis of rotation, and as a result rigid bearings will show characteristic effects of edge loading. Edge loading of the rollers results from the full load being carried by only a small proportion of the nominal effective load carrying surfaces (Figure 9). Self-aligning roller bearings, due to their inherent rolling alignment characteristics, will not show this effect and they maintain their full capacity for useful work (Figure 10).

Inadequate lubrication is often the report from the bearing manufacturer as to why his bearing failed and why he disclaims any responsibility. There are times when certain conditions make it impossible for a bearing to be lubricated and so the lubricant is blamed when actually it was called upon to lubricate the bearing under an impossible set of conditions. Such circumstances constitute special conditions. There is no doubt, however, that the great majority of reported lubricant failures are unquestionable and for which there is unmistakable evidence once the bearing has been completely disassembled and properly inspected by someone experienced in recognizing features of a lubricant failure.

One of the most frequently observed evidences of a lubrication failure is smearing between the thrust ends of the rollers (Figures 11 and 12) and the guide flange of the inner race. Rolling elements have sliding friction at this location and often smearing first appears at this first contact. Smearing is the transfer of metal from the guide flange of the inner race to the rollers and vice versa. The transfer is accomplished by the welding of the rollers to the guide flange and immediate rupture due to the relative motion between these parts without a lubricant film between them so as to prevent metallic contact. There is also sliding contact between rollers and cage pockets that can cause smearing on the body of the rollers (Figure 13). The rollers and races (Figure 14) also may be smeared because the rollers are sta

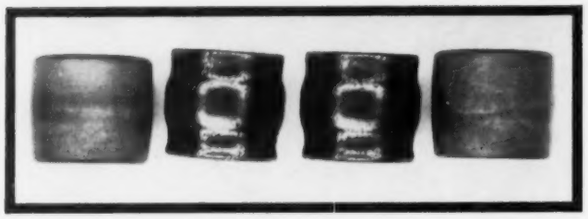


Figure 15

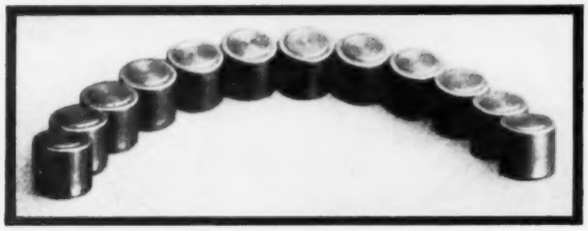


Figure 16

tionary or turning too slowly in the unloaded portion of the races. The lag of the rollers may be from too stiff a lubricant or too rapid acceleration of a machine in getting up to operating speed. Once these highly finished surfaces are smeared, a suitable lubricant does not have sufficiently desirable characteristics to overcome the initial damage and the situation generally becomes progressively worse.

When load and speed conditions are not severe a poor lubricant will often wear the rollers and roller paths to a remarkable degree before the condition becomes distinctly noticeable in the operation of a machine. The contours of the races and rollers are greatly altered and raised ridges appear at the ends of the rollers due to the

Figure 17

Figure 18

clearance provided by the undercuts at each side of the inner race roller paths (Figure 15).

It is possible to distinguish between wear from inadequate lubrication and wear caused by foreign material. Individual parts of a bearing may not indicate conclusively the cause of the wear, but the evidence from all the parts will give a sound basis for a positive statement as to the true cause. The rollers in Figure 16 show wear on ends due to foreign material. The degree of surface polish of the worn areas can indicate the

Figure 19

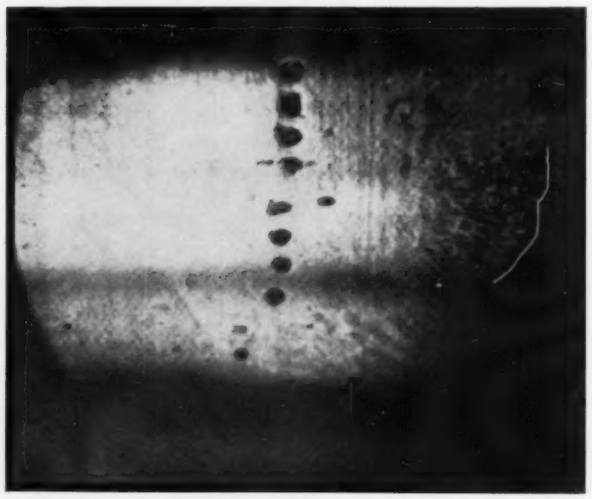


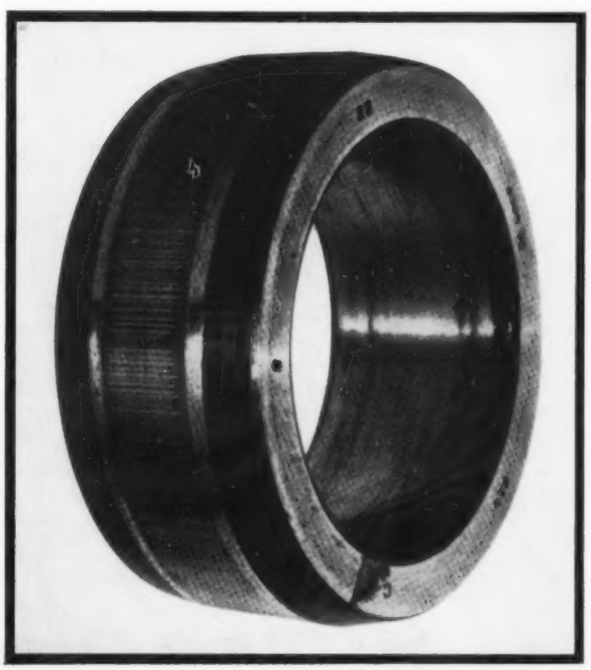
Figure 20

fineness of the abrasive provided the cage pockets, etc., substantiate that the wear came from the foreign material.

Efficient bearing seals must exclude not only foreign material that causes wear, but also water that would cause rust. Corrosion pits in the load carrying surfaces may be erroneously confused with fatigue flaking. The intersecting surfaces that form rust cavities do not meet at such sharply defined intersections as exhibited by fatigue flaking. Liberated rust particles mix with the lubricant and act as a fine lapping compound that actively promotes excessive wear. Corrosion may also result from chemical activity of separated constituents from a broken down lubricant, as shown in Figure 17. The corrosion in a single roller path shown in Figure 18 is quite evidently due to free water in the housing. The rust streaks extend circumferentially under the influence of the rollers in motion.

Within recent years there has been a marked decrease in damage to bearings from the passage of electric currents. The electrical industry has vigorously attacked this problem with definite results. Passage of current for only a short time may cause small craters as shown highly magnified in Figure 19. A heavy discharge may actually melt the steel at the points of current passage between rollers and races (Figure 20). Repeated passage of current develops a washboard surface condition in the roller paths, as typified in Figure 21. The flutings are not all developed and increased in size simultaneously. In the beginning only a few markings will appear and they will be spaced at regular intervals. Gradually the period shifts and flutings fill in between the original markings so as to create the continuous pattern that appears in the advance stages.

Figure 21



PERSONNEL CHANGES . . .

R. V. Mann, since 1925 assistant to the president, Carpenter Steel Company, Reading, Pennsylvania, has been named general sales manager. Mr. Mann joined Carpenter in 1911, resigning in 1917 to enter the United States Army. Following two years as captain in the Ordnance Department, he returned to civilian life as district sales manager, Peerless Drawn Steel Company at Cincinnati and later at Chicago. He returned to Carpenter in 1925.

O. V. Greene, assistant metallurgist, Carpenter Steel Company, has been named manager of tool steel sales. Mr. Greene has been with the company since 1928 and prior to that was metallurgist, Reading Railroad Company.

C. E. Herington has been appointed sales director of a newly created sales service department established by the Meehanite Research Institute of America, Inc., Pittsburgh, Pennsylvania. The object of the department will be to provide assistance in the solution of current and future selling problems encountered by Meehanite manufacturers in the United States and Canada. Mr. Herington, formerly advertising manager, will continue to supervise Meehanite promotional activities.

J. M. Chapple, until recently associated with the Detroit office of Lincoln Electric Company, Cleveland, has been placed in charge of the company's newly established office in Jacksonville, Florida.

W. E. Sault, assistant to general purchasing agent, American Brake Shoe and Foundry Company, New York, died November 29 in that city. Mr. Sault specialized in the purchase of pig iron, scrap, steel, coal and coke. He had been with the company for 40 years.

APPLICATION and MAINTENANCE of Steel Mill Table BEARINGS

By H. E. McGoff

Sales Engineer

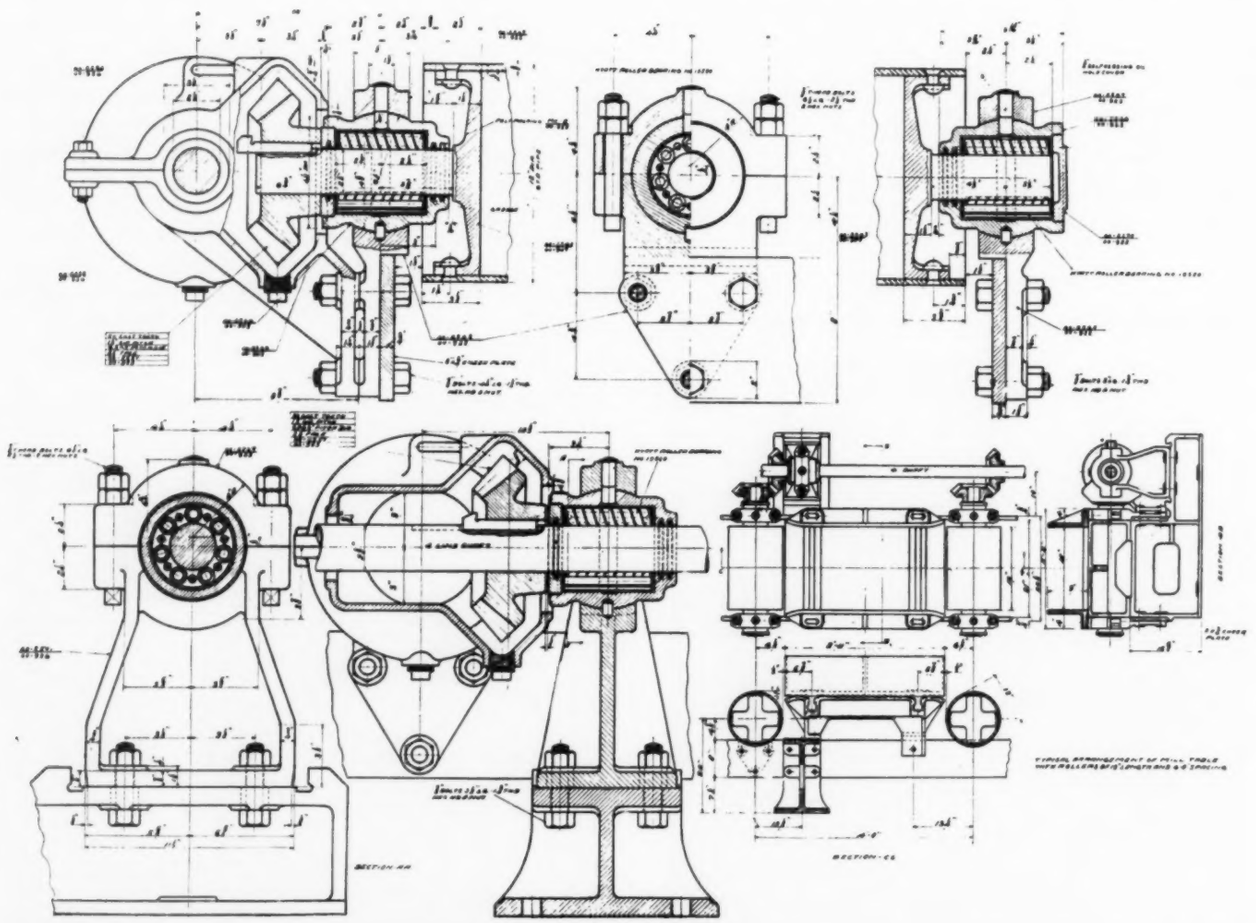
HYATT BEARINGS DIVISION

GENERAL MOTORS SALES CORP.

Pittsburgh, Pennsylvania

▲ PRIOR to 1914 steel mill tables were equipped with brass or babbitt bearings on the table rollers, lineshafts and drives. The first concerted effort to apply roller bearings to steel mill equipment was made during 1914 at the Ohio works of the Carnegie Steel Company. Trial bearings were incorporated in a 14 in. billet mill roller table, and were operated and tested in comparison with plain bearings on similar equipment. At that time the installation was looked upon as a radical departure from the usual method of procedure, but the bearings were installed and a test conducted which showed definite power saving possibilities, a saving of 60 per cent being noted. However, this power saving was not so much the main consideration as was the economy effected by lower maintenance and general operating costs. After two and one-half years of service on this experimental table the roller bearings showed no appreciable wear. This operating test convinced the engineers

Figure 1



at Carnegie Steel Company to include roller bearings on all mill tables to be constructed for the McDonald bar mills.

Following this type of table roller application the steel mill equipment builders and individual steel plants took up the roller bearing idea, and applications were made to the tables of plate mills, structural and bar mills, blooming mills, and more recently continuous strip mills, slabbing mills, and semi-continuous plate mills. Today virtually all the tables installed for any type of rolling mill have roller bearing equipped table rollers, lineshafts, gear drive units, and drive motors.

In the early days of the application of roller bearings to steel mill tables the bearings employed comprised a split outer race or sleeve and a wound or helical roller assembly operating directly on the shaft. These bearings had comparatively large internal clearances when assembled, which probably accounts in some part for the satisfactory performance obtained on early applications, as the design of housings, provisions for sealing the housings against scale and water, and the type of lubricants employed were not up to present day standards. However, many of the mills that pioneered the roller bearing idea are in service today and the bearing performance is very satisfactory.

As the steel industry expanded and new techniques and products were developed the design of tables and bearings were improved to cope with the heavier loads and higher speeds these developments demanded. Today we have mills rolling 54,000 lb. ingots and strip mill runout tables operating at 2200 ft. per min. Obviously the bearings employed in the tables subjected to these loads and speeds must be constructed of different materials and manufactured to greater precision than those employed in earlier applications.

There are two fundamental designs employed today in the application of roller bearings to steel mill tables, leaving out of this discussion any questions of the comparative merits of competitive makes and types of bearings. The first of these two designs employs a bearing comprised of an outer race or sleeve and a roller assembly as did the earlier designs. As the demands on the mill tables became more rigorous, the mill equipment builders availed themselves of alloy steel for table rollers and lineshafts, and heat-treated the surfaces upon which the bearings were to operate, providing a shaft hardness equal to the hardness of the outer race of the bearing. This design has been satisfactory in many mills and the shaft cutting has been negligible. Such a design lends itself particularly well to lineshaft applications where several bearings have to be spaced along each section of shaft. However, the heat-treatment of these shafts requires experience and equipment found in very few shops, and although the mill equipment builders produce the required class of work there is always the possibility that replacements installed in case of breakdowns will not be properly heat-treated or ground to the required tolerances.

The builders of steel mills are therefore employing the second of the two fundamental designs in a majority of the later installations. This design requires a roller bearing comprised of outer and inner races and a roller assembly. This places the responsibility for the rolling surfaces of the bearing entirely on the bearing manufacturer. The application of roller bearings to the table

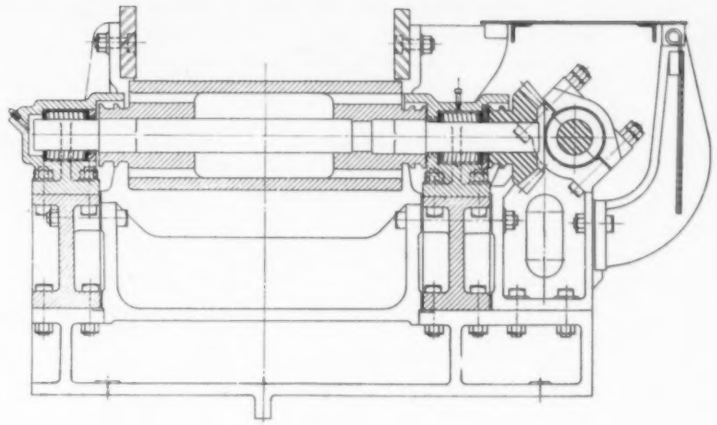


Figure2

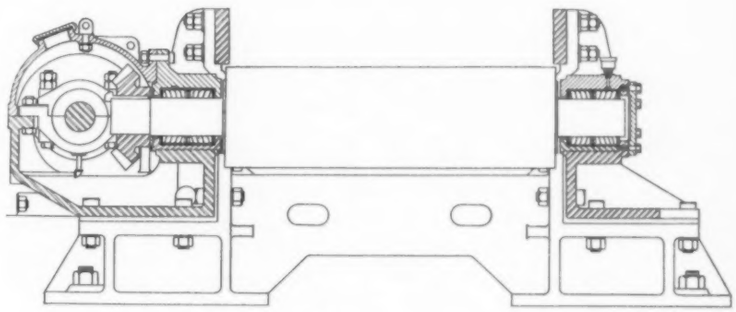
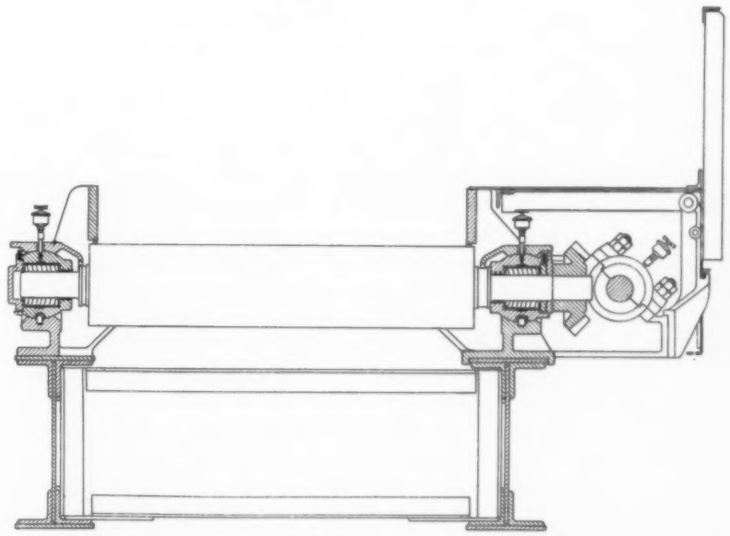


Figure 3

Figure 4



rollers in this design presents no unusual problem, but the application of the inner race to the lineshafts cannot be accomplished with the same practice as that employed on the table rollers. The accepted practice in the majority of the recent installations, where inner races are applied, requires an over-length inner race with a bore permitting the race to be slipped along the lineshaft to the desired location. The race has a key slot in one end so that it can be fixed radially to the lineshaft, and the lineshaft gear is pressed against the other end making the inner race an integral part of the lineshaft. The over-length race also lends itself to a housing design providing for the use of the hardened and ground surface of the race as a wearing surface for the grease seals.

The satisfactory performance of any roller bearing depends upon the accuracy of the application. The shaft diameter and housing bore must be held within the tolerances specified by the bearing manufacturer. However, the personnel of the equipment builders and the steel mill shops have had many years of experience in the application of roller bearings, and practically no difficulty resulting from poor bearing fits has been encountered.

For some types of table applications it is desirable to provide for the alignment of the bearing after the original assembly. This can be accomplished very satisfactorily with a ball and socket or spherical type housing which will permit the bearing to maintain its alignment with the shaft center line under any circumstances. It should be noted, however, that in the majority of the table installations such a precaution is not necessary.

The type of seal required for the protection of roller bearings in steel mill tables depends upon the service the table will be subjected to. For applications where water and roll scale are encountered seals that prevent the introduction of such foreign matter into the bearing should be employed. There are several types of unit seals that meet these requirements and very satisfactory results have also been obtained with labyrinth seals and some types of felt rings. However, an air-bound bearing, which prevents the lubricant from getting to the rolling or retainment surfaces, can develop from the sealing of bearing housings unless proper precautions are taken. When tight fitting unit seals are employed an air vent should be provided which will be so located as to allow the passage of no impurities into the bearing, but will permit the expulsion of the air in the housing when the lubricant is forced in.

After the proper application of roller bearings to steel mill tables, the maintenance of these bearings becomes a matter of proper lubrication. The primary requirements of a lubricant for roller bearings are purity and sufficiently light body under all operating conditions to flow between the rollers and offer no interference to the perfect functioning of the bearing either at starting or while running.

The greases recommended shall be homogeneous combinations from refined mineral oil and soap and shall not contain any filler such as clay, talc, whiting, asbestos, wood fiber, graphite, etc. Greases containing any solid fillers are positively harmful and should not be used in connection with the lubrication of roller bearings. Further than this each application presents its individual requirements due to heat, scale, speed, etc., and the selection of the lubricant must depend upon the combined experience of the operating personnel and lubrication engineers.

DISCUSSION

FOR PAPERS OF MESSRS. VAN PELT, WECKSTEIN, MURRAY, AND McGOFF PRESENTED BY

J. M. DEPP, *Lubricating Engineer*, Carnegie-Illinois Steel Corporation, Braddock, Pennsylvania

O. P. ADAMS, *Superintendent of Maintenance*, National Tube Company, McKeesport, Pennsylvania

J. M. ASHLEY, *Superintendent*, Electrical Department, Republic Steel Corporation, Youngstown, Ohio

T. R. MOXLEY, *General Master Mechanic*, Wheeling Steel Corporation, Steubenville, Ohio

F. H. McCURDY, *Manager*, Industrial Division, Brooks Oil Company, Pittsburgh, Pennsylvania

H. D. ROBB, *District Manager*, Industrial Division, Timken Roller Bearing Company, Pittsburgh, Pennsylvania

C. S. BULLIONS, *District Chief Engineer*, Industrial Department, Socony-Vacuum Oil Company, McKees Rocks, Pennsylvania

S. M. WECKSTEIN, *Chief Engineer*, Timken Roller Bearing Company, Canton, Ohio

A. S. MURRAY, Engineering Department, Steel Mill Division, SKF Industries, Inc., Philadelphia, Pennsylvania

A. A. VAN PELT, *District Manager*, Norma-Hoffmann Bearings Corporation, Pittsburgh, Pennsylvania

H. C. GOODRICH, *General Foreman*, Electrical Department, Carnegie-Illinois Steel Corporation, McDonald, Ohio

V. A. MENAGLIA, *District Sales Manager*, SKF Industries, Inc., Pittsburgh, Pennsylvania

JAMES FARRINGTON, *Superintendent*, Electrical Department, Wheeling Steel Corporation, Steubenville, Ohio

T. B. McELRAY, *Superintendent, Light and Power*, Carnegie-Illinois Steel Corporation, Youngstown, Ohio

J. M. DEPP: The papers present a clear view of the design problems with which we are faced in the construction of new equipment. In regard to the operation and maintenance of anti-friction bearings, I believe that failures due to lubrication are mainly lack of or careless handling of lubricants rather than failure of the lubricants themselves. Overloading is also a frequent cause of many failures.

O. P. ADAMS: These papers have brought out a number of things that make us realize the bearing manufacturers know something of our problems in steel mills. The designs show careful attention to the problems introduced by the thermal expansion of parts. If the illustrated principles had been applied in all past applications, a number of difficulties encountered would have been eliminated. Even in equipment furnished today, this matter of thermal expansion is not always adequately provided for.

J. M. ASHLEY: I am sure every steel man has a group of sleeve bearing motors that he would like to

change over to roller bearings. However, the cost of the larger sizes is startling and must be justified. We are at the present time doing a lot of this work. I personally would like to hear some discussion regarding roller bearing application to crane track wheels.

T. R. MOXLEY: The problems with anti-friction bearings brought out by these papers are very interesting to me, for we have had them all and possibly more. We still use the human element in our operations and when we find a way to eliminate that, I think our troubles will be very much less. In my experience with anti-friction bearings, I feel that we have never found much wrong except for the thrust load. If we had failures, we could trace them back to some element of the thrust load.

F. H. MCCURDY: I do not agree with Mr. Weckstein, as to present day seals keeping water out of roller bearings. It is true, the drawing shown by him looks as though water could not get into the bearings, but it is a fact water does get into most bearings, thus causing a lot of troubles well known to the steel industry.

One common method of trying to keep water out of a bearing is to fill the bearing full of grease, thus hoping there will not be any room left for water; this of course is a bad practice, causing the bearing to run hot.

We in the oil industry are asked continually to make a lubricant that will lubricate efficiently in roller bearings where water gets into the bearings. This of course is one of the toughest jobs we have to encounter, and putting it mildly, it is a serious problem. Better seals on roller bearings would result in more efficient lubrication of roller bearings.

H. D. ROBB: Regarding Mr. Murray's paper, I take exception to his statement that the majority of anti-friction bearing failures are due to fatigue. We believe that most maintenance can be attributed to bad lubrication, such as wrong type, wrong method of application, wrong quantities and inadequate seals.

C. S. BULLIONS: Lubrication service has coöperated with the makers and users of anti-friction bearings to achieve the present-day success of these bearings for steel mill duty. It is admitted now that bearings of insufficient capacity were often used in early applications to continuous mills. The overload condition gave rise to momentary deformation at the pressure area and molecular heat, tending to produce a weld. It became necessary to introduce sulphurized lubricants to reduce this welding action.

Later, as larger bearings were used, the welding action was replaced by surface scuffing, which has been described in this meeting. Sulphur could not prevent this action, nor did it assist in smoothing the bearing surface. Leaded lubricants, acting as mild lapping agents, were found to meet this condition with reasonable satisfaction.

As the capacity of the bearing is increased, relative to its required duty, the necessity for the so-called "extreme pressure lubricants" decreases.

The problems presented to the petroleum industry by the bearing manufacturers led to extensive laboratory studies which have produced valuable new products and clearer concepts of the structure of lubricants.

The lubrication engineer should express his appreciation of the active interest which the bearing manufacturer has taken in developing better lubricants.

S. M. WECKSTEIN: I might comment on a few of the statements that have been made. Starting with the statement about bearings being experimental, I think that was true to a large extent, but on the other hand I think you should give the bearing manufacturers the benefit of the doubt. The mill builders did not know what they were looking for and I think we were all equally guilty in that respect. Probably all of us were experimenting at some stage of the industry, and who wound up the loser, I do not know.

On the question of lubrication and the comments made by engineers of the lubricating companies, I want to say this: If it had not been for the efforts of the manufacturer's research, you would not have a satisfactory lubricant that would enable automobiles and heavy equipment to operate at the loads and speeds we have at present. We had a difficult time to get lubricant manufacturers to start on a high pressure lubricant. It was hard to make. Today they are making lubricants that are very desirable and finding them quite stable and they are really doing the job in the field; and I know definitely that if we did not have these lubricants on the market at present, we could not operate automobiles, trucks or many other kinds of equipment. The lubricant manufacturers have done a good job.

As far as the seal is concerned, I think the bearing manufacturers are trying to do the best job they can in the way of seals. When seal manufacturers first went into the business of making seals they did not know where these seals were going or what they were going to do. Most of those manufacturers have now investigated the jobs and are engineering the seals for the job. We are getting better seals than in the past.

A. S. MURRAY: Referring to Mr. Robb's statement, I did not mean to leave the impression that a large part of the bearing failures were fatigue failures.

We agree with Mr. Weckstein's statement about the bearing seal. We are interested in a better seal. Very often when a job has given us trouble, we have found the fault lies in the seal. Possibly the size of the seal had been cut down to look good on the drawing, but was bad in practice, and that provided the background for some of the specimen failures.

A. A. VAN PELT: Reference was made to bearing grease. There was so much trouble with it that we found we practically had to get into the manufacture of grease ourselves. It is an inhibited grease which we have developed to prevent oxidation for a long period of time. Quite some years back if we purchased grease to put into our sealed bearings, we found within a period of time—which might be as short as 30 days—this grease would harden in the bearings on our shelves. All of the grease companies were interested to a certain extent, but any grease they could furnish would not solve the problem. Therefore, about seven years ago, we established a grease laboratory of our own, began investigating and found these greases oxidized rapidly and that some form of inhibitor had to be put into the grease to give a longer grease life. We have developed this grease to a point that we now know we can get exceptionally long life out of grease. We have records where it has

been in operation five, six, or seven years, operating at a temperature of not over 150 degrees F. I think other manufacturers will bear me out in the statement that for every 17 to 20 degrees operating temperature over 150 degrees F., you cut the life of your grease in half regardless of what the initial life was.

H. C. GOODRICH: A few years ago, the manufacturers of ball bearings were very insistent that their bearings on motor installations be disassembled and washed out at least once a year. They even fastened tags and metal plates to the bearing housings recommending that this be done. Now, so far as I know, it is not the practice of operating men to touch these bearings unless we suspect excessive wear or some other distress. I would like to know the opinion of some of you bearing men and grease men as to the necessity of going to all of this trouble.

C. S. BULLIONS: With reference to the question about changing bearings, a service engineer for a lubrication concern is merely a consultant; his views are accepted or left alone. I would say that conditions have a lot to do with how often to change a bearing. In coal mines in this area, glass plants and foundries and mills, we have a highly abrasive material in the atmosphere, and with all regard to sealing of various types, air carries that material in. There is bound to be some dust enter and that dust is abrasive. As to how often to change, you find out what your bearing conditions appear to be and if necessary have the grease changed. If you are using a good quality, it does not pay to have it done too often. To tear down a machine and grease it is foolish, unless you have a condition of dust getting into the bearing.

V. A. MENAGLIA: Regarding the development of a suitable grease, I wish to leave this simple idea with you, namely, that the main difficulty towards developing suitable greases can be attributed to the fact that we are unable to obtain a suitable stable oil that will not break down due to oxidation. In other words, it is not primarily the fact that greases break down due to the separation of the filler or base from the oil, but the fact that the oils used in cooking up the greases oxidize with attendant instability, and eventually break down.

I do not mean to create the impression that there are no such things as stable oils, since there actually are, but we, the bearing companies, have been unable to obtain them consistently, since it is our experience that even the oil producers do not know which are the stable and which are the unstable oils. Any grease made up with an unstable oil, or one which will tend to oxidize, will in due time give trouble.

As stated by Mr. Van Pelt, some of the bearing companies were driven to the necessity of developing their own greases, and to prevent oxidation of the oil they utilize what is known as an inhibitor. It is necessary to resort to the use of this inhibitor until the time arrives when the oil companies can furnish with certainty and consistency suitable oils for the preparation of grease which will not oxidize.

The situation at present is such that it is merely due to chance if one obtains an oil that will not oxidize. In searching for suitable greases for utilization in cartridge type bearings, we have several times felt that we had the correct answer with a suitable grease, and after the bearings have been in service for a moderate length of time we find that oxidation has set in which proves only one thing, that the oil used in preparing the grease was unstable. I cannot stress too strongly that as soon as the oil companies can with certainty furnish oils that will not oxidize our grease trouble will be materially lessened.

JAMES FARRINGTON: We have been using anti-friction bearings since 1909 and we firmly believe in them, but do not consider them an actual specific for all of our requirements. The whole thing with anti-friction bearings hinges on getting a bearing large enough to do the work under the worst conditions and not under average conditions, and above all we must have the exclusion of foreign material. We had trouble on bearings of ladle cranes which had standard bearings, with end thrust. We got five different types of bearings with a different type of end thrust absorption, and at the end of five years, all five of them were still in service, showing it was due to the picking up of foreign material from the thrust bearing.

On certain mill type motors you can get excellent results by transferring from sleeve to anti-friction bearing. We have changed quite a number and have had no failures, but on general purpose motors on which we have put anti-friction bearings and where there was an extension of the shaft for coupling drive or for chain drive, we would get vibration in the shaft that was reflected back into the bearing. We have changed those anti-friction bearings back to sleeve bearings and have eliminated our trouble.

I do not believe anything has been said pertaining to the relative merits of anti-friction bearings and babbitt bearings on main drive. We made a test on that and found that the advantage of the anti-friction bearing was principally in starting up the mill, and up to the normal speed the anti-friction load was within two per cent of full load for the sleeve bearing.

As regards changing bearings on motors, we have run many of our motors as long as five years without taking them down, but that all depends upon the condition, and whether there are indications of foreign material getting in. We figure foreign material is our greatest enemy, and in places where we had steel dust or cement dust we changed them in five years, but have found the bearings in excellent condition after five years' service. So we no longer take a motor down on account of its bearings, unless we find when testing there is play in the bearing; then we take it down for examination.

T. B. MCELRAY: We had a lot of sad experiences with that first installation on our continuous mill table back around 1914, due to not having the proper thrust bearings or proper cartridges. We had many failures, but the failures and experience gained by those failures were very valuable to our company and to the bearing manufacturers in determining the advisability of equipping the tables on the new mills.

I believe we were also among the first to install roller bearings on bridge track wheels on ladle cranes. We did not have the necessary experience to select bearing that would take care of the end thrusts and shock loads; we found the bearings selected were not large enough, and

had to try several schemes of bearing combinations before getting satisfactory results.

From that experience we have found that a good yard stick to use is to take the bearings that the manufacturer recommends for the weight and speeds, and increase it a couple of sizes. We have had very few failures since adopting this system.

We also feel that a bearing should last at least the life of the track wheel. We may be able to use a smaller bearing on track wheels when we get all rails welded at the joints and better girder construction on old buildings. We all must admit that a lot of cranes have to run over pretty bad track conditions.

We have had a number of armature shafts break on motors that have been changed over to roller bearings, some of which were built up and returned to size, and never were known to break with babbitt bearings. I would like to know if any one in the meeting has had this experience.

S. M. WECKSTEIN: With reference to changing oils, greases and bearings, there have been quite a number of statements made about foreign material getting into bearings. When a mill is idle condensation occurs and that has been responsible for quite a large number of bearing failures, especially on heavier equipment in mills. We recommend that when any piece of equipment is shut down for any length of time, if the equipment is grease lubricated, that the grease be forced out and new grease put in during the time the equipment is not in operation. If oil lubricated, oil the bearings before stopping and starting up and you will find considerable life left in the bearings.

Mr. McElray mentioned that if bearing manufacturers and frame manufacturers were consulted on the size of bearings it would mean doubling the life of the bearings. All anti-friction bearings are selected and designed on the basis of fatigue life. We know more about that now than we did 15 or 20 years ago. There is quite a difference between doubling the life of a bearing and doubling the size. You do not have to make much of an increase in the size of the bearing to double its life. It does not cost much to double its life if proper attention is paid to the selection and application of the bearing.

H. D. ROBB: I believe in this discussion that too much emphasis is being placed on bearing failures. I do not have any recent figures but know that a few years ago our information showed only .4 of 1 per cent failures, and I assume that the same percentage holds good for the other bearing manufacturers. Let's talk of the good points of anti-friction bearings.

S. M. WECKSTEIN: In the future when we buy equipment, if it is at all possible, let us determine whether the maximum and average load is that of today, of 10 years ago or of 10 years in the future. I have been in the game long enough now that I can name mills where formerly the average material rolled was 30 in. wide and is now 60 in. wide, and yet we still expect to have the same bearing life. Those bearings were satisfactory years ago but not satisfactory today because of the changes made in the mill, both because of increase in rolling speed and increase in rolling practice. So when we condemn the bearing manufacturers or motor manufacturers about a larger number of failures than we had 10 years ago, let us keep that in mind.

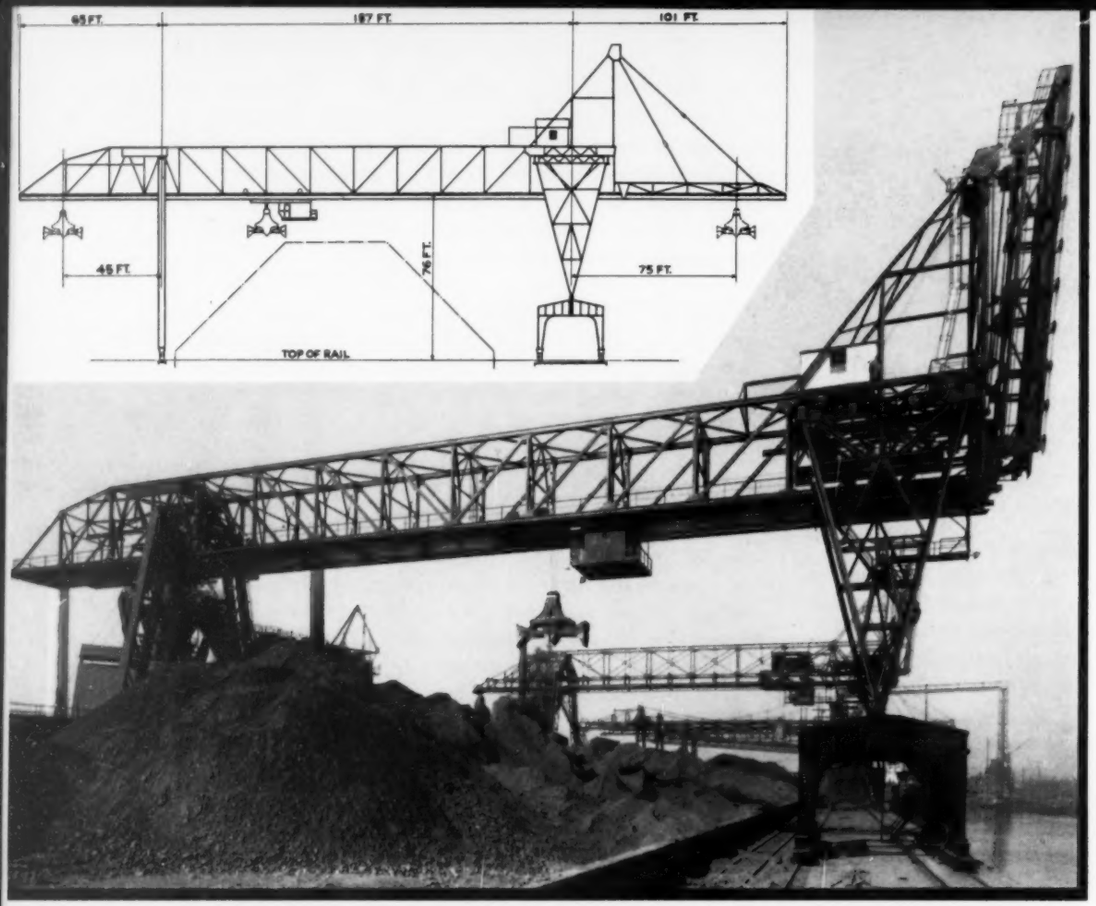
C. S. BULLIONS: Some time ago I listened to a paper on the subject of increasing the strength of shafts when anti-friction bearings are being put on the shaft. After that I paid more particular attention to breakages where bearings had been installed on motors that previously had plain bearings and found that a number of cracks occurred at the edge of the bearing due to fatigue of the metal.

S. M. WECKSTEIN: The cause of trouble that occurs when changing from plain bearings to anti-friction bearings is that we often forget, when making such a change-over, what the machine was originally designed for. We make the change from plain to anti-friction bearing and expect to get away from our troubles and instead get into a lot of other troubles. You people are speaking of mill motors, but the bearing manufacturers have had a lot of other experiences. Let us take jaw crushers used in the rock crushing industry. These were originally built with plain bearings. A 5 in. diameter shaft had a bearing 6, 7, or 8 in. long and then a big flywheel overhanging the bearing. These plain bearings were replaced with anti-friction bearings of about half the above width. The position of the flywheel was not changed. Failures of shafts and flywheels occurred and did not stop until the manufacturers who made these changes had increased the shaft sizes considerably and moved the flywheels close to the bearings. It may be that you are getting the same thing on motor change-over. We have had change-overs on machine tools. When making a change-over on grinding machines by putting anti-friction bearings on a spindle, you should change the entire design of the machine if you expect good results. At best any change-over is a makeshift.

On the question of cold working, I think you can increase the life by cold working. Whenever you make a press fit you get a concentration of stress. By metal spraying or cold working shafts, if properly done you can increase the strength of the shaft. In welding up shafts you have to do it in a certain way to keep away from sharp stress concentration.

A. A. VANPELT: A remark was made about changing over a general purpose motor and getting increased deflection of the shaft. We design our flange units so that the outer end of the casting is in the same position as the face of the old sleeve bearing hub. In practically all cases the center line of the bearing is thereby brought considerably closer to the center line of load, with the result that the resistance to deflection, of the shaft, is actually increased as much as 15 per cent.

T. R. MOXLEY: We got better results on armature shafts and table roller shafts, after welding, by bringing the center line closer to the seal, but even then we got breakage. We installed an annealing furnace or normalizer, and whenever we weld shafts on rolls, we always normalize the shaft after it is done, and have eliminated 90 per cent of the breakage by normalizing.



ORE

By George F. Wolfe

DRAVO CORPORATION

Pittsburgh, Penna.

Presented before A.I.S.E. ANNUAL CONVENTION, CLEVELAND, O. September 23-24-25, 1941

Figures 1 and 2—This typical bridge has an open portal in the pier leg to allow the movement of cars.

▲ DURING the past two years, the author has had the opportunity to visit a large number of steel mills and unloading docks and to make inspections of all of the bridges at these mills and docks. Through the coöperation of the various managers of the plants and docks visited, it was arranged to contact directly the chief engineers, blast furnace superintendents, dock superintendents, and even the operators of the equipment visited.

As the result of these various visits and the numerous contacts made with the operating personnel, a clear picture was secured of the entire bridge problem, and the information given in this paper is based not on the author's personal opinion but on the consensus of opinion of a large number of men who are working directly and constantly with the equipment under discussion.

There is probably no piece of mechanical equipment which is subjected to more constant usage under maximum loading conditions than is the average ore bridge. The conditions prevailing during the past year, and which will probably continue for a considerable time in the future, are not conducive to proper maintenance as the majority of the bridges are not only working to full capacity, but are being worked continuously without the opportunity of giving them the usual repairs. Added to this condition is the fact that the average bridge is already in a state of advanced life where repairs are of a greater magnitude and often dictate a complete overhauling of the entire structure.

USEFUL LIFE OF BRIDGES

One of the questions asked the author on his visits to the various bridge installations had to do with the expected useful life of bridge equipment. This is a most difficult question to answer, particularly if one is engaged in the sale of equipment, but the survey made gave an answer which is quite independent of any personal consideration. Of the bridges inspected, 42 per cent had an age of active service of over thirty years, with a number of these approaching very closely the forty year period. Of all the bridges inspected, only 11 per cent had been built within the past fifteen years. When one considers that a structure of this type has been subjected to practically constant usage under extreme stress conditions and under alternating stress conditions, there is not much doubt in the mind of the average engineer that old bridges may become hazardous from the safety viewpoint. There have been several failures of bridges which have occurred under normal operating conditions, and in most instances these failures have taken place on bridges which are in excess of 30 years old. There is no practical method of inspecting the materials in such structures, but there is well defined knowledge as to the effect of constant alternating stresses; and present day laboratory experiments show that joints and main members will fail after a definite number of alternating stresses and under definite stress conditions. It is respectfully submitted, therefore, with these facts in mind, that the probable safe age for a bridge operating under constantly alternating stress conditions can not be much more than 30 years. Without further elaboration on this point, we leave with you the reminder that approximately 42 per cent of the bridges now in use are more than 30 years of age.

CAPACITY OF BRIDGES

The capacity of bridges is determined in large measure by the size of the buckets, with buckets varying from 5 to 17 ton capacities. Of the bridges inspected, 45 per cent had buckets larger than 10 tons, with the maximum being mostly 15 tons, and only three bridges were found with bucket sizes in excess of 15 tons. In many cases,

the bucket sizes have been increased over the original design, thus subjecting the structure to loadings which were not anticipated. Several bridges now under construction are utilizing buckets varying from 17 to 20 tons in capacity, and we believe that this is a very proper move, inasmuch as the capacity of the bucket, and particularly on bridges of fairly long spans, does not greatly alter the overall cost of the bridge. In some instances, the capacity of bridges has been increased by replacing the original trolleys with trolleys of aluminum or low alloy construction and utilizing more modern buckets of lightweight construction. This is a very proper procedure, but, unfortunately, conditions are such at present that the sources of supply for such material are limited, and it is practically impossible to secure materials for such alterations. Capacities can also be increased by changing the speeds of the various operations and particularly the speed of hoisting and trolley travel, but these again require heavier weights and should not be considered without making a thorough check of the structure to make sure that the increased loading does not increase working stresses to a critical point.

REPAIRING OF OLD EQUIPMENT

Since ore bridges are subject to practically constant usage, the repair is a difficult problem, nevertheless, a very necessary operation. The average bridge is used almost constantly during the summer season, with the result that major repairs are made during the dull season and under most unfavorable weather conditions. There is also an almost universal practice among bridge owners to perform these repairs with the bridge operating crew. From the standpoint of constant employment, this is a most excellent idea; but from the standpoint of securing the best possible workmanship, we do not believe that it is to be too highly recommended. Familiarization with the operations of a machine does not necessarily qualify the operator as a first-class mechanic, and our best illustration of this point is the fact that most of us have quit repairing our own automobiles many years ago and leave the servicing to skilled mechanics.

The almost universal usage of welding as a repair tool is facilitating bridge repairs to a considerable degree; but in many cases, welding is being used without proper supervision and without full consideration of the effects of welding. This repair by welding was illustrated at one mill where the superintendent of maintenance pointed out a heavy crane which was being increased in loading from its original capacity of 150 tons to a capacity of 250 tons. Since this gentleman had faith in welding, he felt that it would be quite sufficient to increase the strength of these crane girders, by running a welding bead up the vertical edges of the web splice plates, which were located at the center of the span of the girders. The author, who likewise has great faith in welding but possibly more experience in both welding and design, pointed out the fact that the addition of the bead on the edges of the splice plates did not increase the strength of the girder, since stresses of girders are carried mostly by the flanges and not by the webs, and also pointed out the fact that the running of the bead up the side of the splice plates would not only not increase the overall strength, but would loosen all the rivets adjacent to the weld and decrease the original strength very considerably. It is to be hoped that the alterations as originally contemplated were not made.

In the use of welding on riveted structures, it is highly deisrable that no welding be done in the neighborhood of existing rivets, as the welding will cause contractions which will, in most cases, relieve the rivets of load and pick up the entire stress in the welding. Where it is necessary to weld around rivets, sufficient welding should be done to take all of the stress and figure that no stress is carried by the existing rivets. In welding on structures which have been subjected to many years of alternating stress conditions, extreme care should be taken in the location of the welds; and as a general rule, the running of beads across a member should be avoided as this causes a crystallization in the

Figure 3—All wheels are driven through a fully enclosed worm drive as illustrated here.

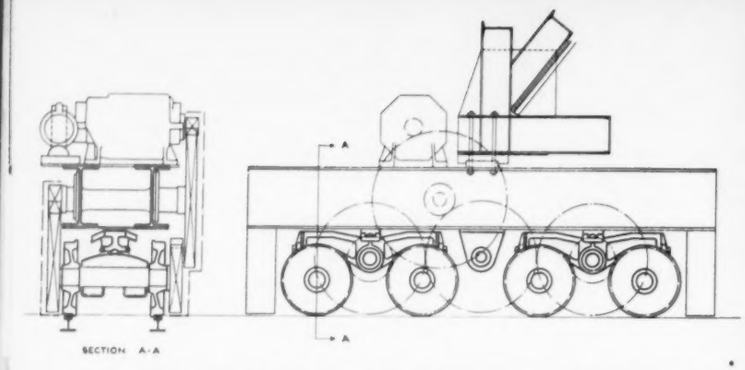


Figure 4—Trucks and drives may also be equalized by a geared drive as here shown.

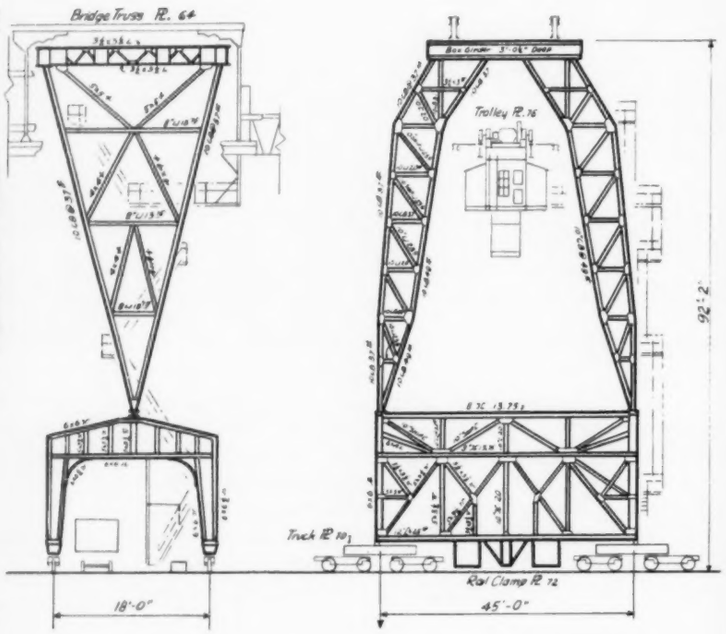
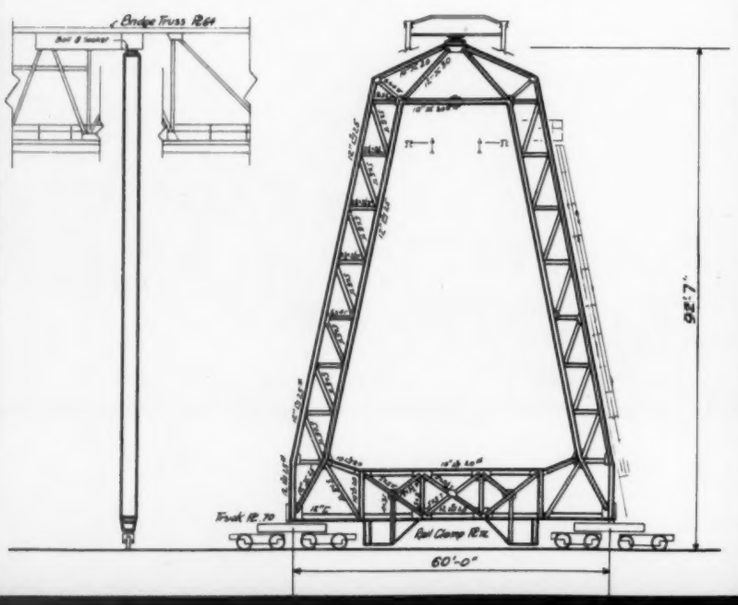


Figure 5—The pier leg stabilizes the bridge structure by supporting it at four points.

▲

Figure 6—The shear leg terminates at a point on the center line of the bridge structure.



member and very often failures will result. To avoid subjecting existing members to such conditions, it is recommended that where welding is necessary, such welding be done diagonally across the members so that very little of the net cross section is affected at any one place. In some installations, welding has been done very successfully on trolley rails and, particularly, in building up of the ends of the rails at the joints. This welding requires extreme care and a skilled operator, since the work is being done on material of a high carbon content. However, with the combination of a skilled operator, proper welding equipment, and an electrode suitable for the material being welded, excellent results have been secured in many cases; but unless all of these conditions are adhered to, the results will be doubtful. The manufacturers of welding equipment and weld wire give these problems constant study and are usually in position to give proper advice as to the type of electrode to be used in each specific case.

MODERN BRIDGES

During the past fifteen years, comparatively few bridges have been built, but those bridges which have been erected during this period show a general similarity of construction, which we may term modern ore bridge construction. Most of the newer bridges are of the skew type with skew limit of approximately 5 degrees and are equipped with trucks having 100 per cent drive. Bridges used solely for transporting material to stock from cars or pits and from stock to charging cars usually have fixed cantilevers except in the Lake district, where bridges are used for both unloading and stocking, in which case they have lift booms at the unloading end.

A typical bridge built a few years ago in the Lake district is illustrated in the sketch shown in Figure 1 and also in the photograph shown in Figure 2. A duplicate of this bridge is now under course of construction for the same owner, with the only change being that the trolley will be turned around so that the operator will face the water, which will facilitate the spotting of the bucket into the hatch openings of the vessels bringing in the ore. This particular bridge embodies practically all of the features found in modern bridges as well as an open portal at the pier leg to provide for the movement of cars on the docks beneath this portal.

TRUCKS AND TRAVEL DRIVES

A fully enclosed worm drive was incorporated in the design of this bridge as shown in Figure 3. Following modern practice, all wheels are driven with a single motor driving the wheels at each corner of the portal and also at each end of the shear leg. These worms are fully enclosed, running in oil, and provide a very smooth and quiet action and increase the safety factor of the bridge materially against wind storms. A more conventional method of equalizing trucks and drives is shown in Figure 4, wherein is illustrated a standard eight-wheel, two rail, fully equalized geared drive. In both the case of the worm drive and the gear drive,

simplicity of construction has replaced the former elaborate drives, such as the old line shaft drive driven by a single motor, usually located at the center of the truss span and tied into the wheels by a series of elaborate line shafts, bevel gears and couplings. One of the bridges with this type of drive showed a total of more than 200 bevel gears, which were a source of constant upkeep; and due to the numerous parts involved and the looseness in these many connections, a considerable period of time elapsed after the starting of the motor before the starting of the bridge. These modern constructions eliminate as far as possible the use of bevel gearing except in the case of the worm drive, where proper housing makes provision for the retention of the gears in their relative positions. All drive motors are equipped with spring set, electrically released brakes which aid in holding the bridge against wind stresses when the bridge is not in motion.

PIER LEG AND SHEAR LEG

The pier leg, which gives stability to the bridge structure, is illustrated in the sketch shown in Figure 5. The truss structure is supported at four points on the pier leg with these points of support consisting of flat plates engaging each other to provide a surface for the superstructure to slide on the leg when the bridge is skewed. The best construction for this type of connection consists of bronze plates sliding on steel plates, with proper lubrication and a protective housing to keep dust and moisture out of the contact surfaces. The shear leg, as shown in Figure 6, consists of a one plane construction terminating at a point on the centerline of the bridge structure. The superstructure at this end is supported on a single ball and socket joint with the socket provided with a bronze bushing in which a hemispherical steel casting rotates. Lubrication is provided at this point, and this type of construction provides all the play necessary, both for the rotation at the joint in the horizontal plane and the inclination of the shear leg caused by the skewing of the bridge. In both the case of the pier leg and the shear leg, these improved methods of supporting the superstructure by means of the sliding contacts and the ball and socket joints are distinct improvements over the former method of eye bar suspension. The eye bar suspension was not a safe construction as the eye bars very often developed lengthening and breakage and were a source of maintenance which has now been eliminated. Safety factors are provided in the more modern construction by the use of king pins at each leg, which keep the bridge centered at the pier leg and which prevent uplift at the shear leg.

TRUSS STRUCTURE

The truss structure of the modern bridge consists largely of beam construction with the use of single piece members wherever possible, as compared with the built up latticed and battened construction on the older bridges. This change in the shape of members eliminates a large part of the maintenance costs, as the cleaning and repainting operations are greatly facilitated. In general, there are two types of transverse bracing and track suspension systems in use, one of which, the open portal type, is illustrated in the sketch in Figure 7. We believe that this is the most popular type of construction, and it reduces wind stresses considerably from those in the suspended type of track which is found on many of the older installations. Adequate horizontal stiffening of the structure can be developed just as well with this type of construction by proper design as can be developed in a suspended type of track, and this horizontal stiffness is greatly facilitated by the use of a

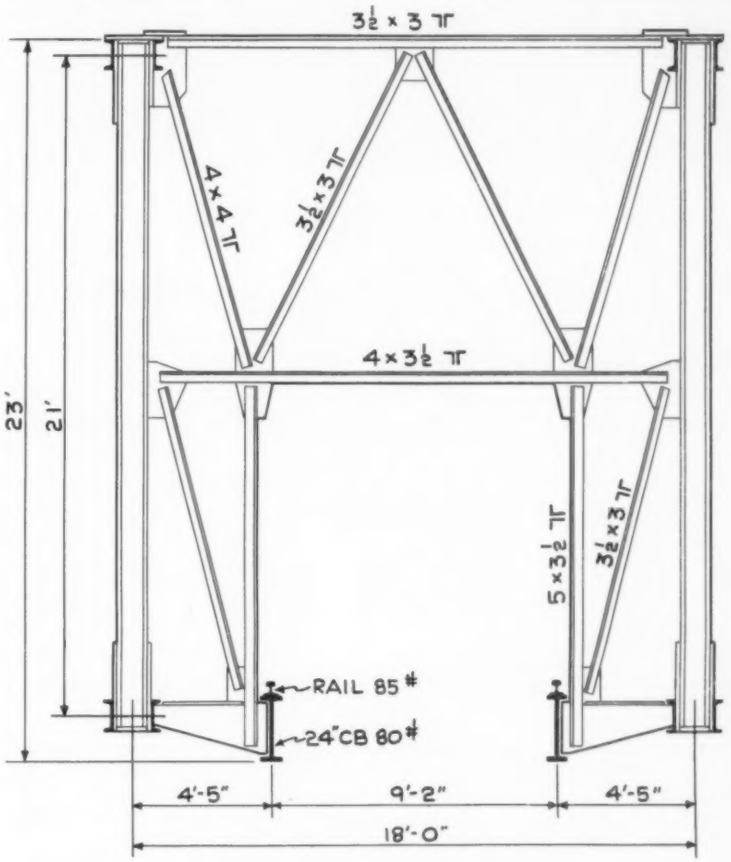


Figure 7—This drawing shows the portal type of transverse bracing and track suspension system.

compression horizontal bracing system in the top chord, which can be seen in the photograph shown in Figure 2. The same usage of rolled beams in lieu of built up angle and plate sections is carried into the construction of the legs, with the result that the modern bridge has an all-around clean-cut appearance and lends itself readily to proper maintenance.

TROLLEY TRACK

Various types of trolley track constructions have been used, and in general, no track has ever proved entirely

satisfactory except for a new construction which has been little used. There are several fundamental principles of design which have not been incorporated in the older structures and which experience has dictated, rather than the ingenuity of any single designer. The general practice has been to locate the joints of the track beams at the points of support, and in many cases, to splice the rails within a foot or two of the track beam splice. More modern designing methods and experience

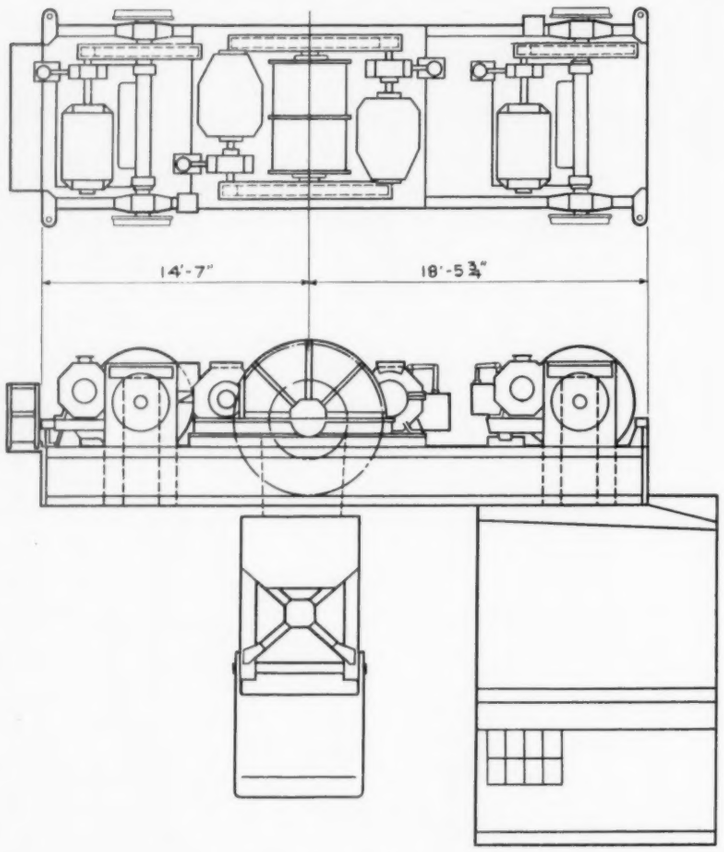


Figure 8—This man trolley is used on a 15 ton bridge equipped with a two-line bucket.

with structures built as above indicate that it is most advisable to splice the track girders at approximately the quarter point of the span in order to keep rotation out of the connections, and to splice the rails at the midpoint of the span with splices staggered on the opposite rail by a full panel, in order to obtain all of the possible benefits. In splicing the track beams, the splices should develop the full strength of the beams in order to secure continuous beam action, and rails of as long length as possible should be used to secure a minimum of rail joints. Many trolley track rails have been riveted to the track beams, but this construction is not advisable as it is impossible to keep rivets tight under the stresses involved. It is highly preferable to fasten the trolley track rails to the top flange of the track beams by means of welding steel clips to the beams. Various forms of steel clips are available, and one can use either the standard rolled steel rail clip which has been used for bolting or specially designed clips which come up to the bottom of the rail head and provide lateral support to the rail. It is not recommended that rails be welded directly to the track beams, although this has been done in some cases with fair success. This construction of welding a rail of high carbon content directly to a beam of low carbon content can be done, but requires unusual skill in welding, and even then if subjected to sharp impacts, will probably break loose due to crystallization in the base of the rail at the edge of the fusion zone in the weld. A more modern track construction which has been used on railroad track construction consists of the use of steel tie plates with the top of the plates inclined on a slope of 1 to 40 toward the center of the track. The rail is held to the tie plate by means of a patented bolted construction, and an elastic material is placed between the tie plate and the rail. This construction has been used on only one bridge, but has been very satisfactory; and since the inclination of the top of the tie plate causes the rails to incline slightly toward the center of the bridge, the flanges of the wheels of this particular trolley have never come into contact with the head of the rail, as this slight inclination is sufficient to keep the trolley centered at all times. This construction appears to have considerable merit and will probably be used on future bridges, provided the owners see fit to invest the proportionately small amount which will insure a good permanent construction. The same type of track with the tie plate spiked to wooden ties has been used for the bridge travel tracks with very good success.

TROLLEYS

The almost universal practice of modern bridge construction is the use of man trolleys, with the operator and all controls as well as the hoisting equipment located on the trolley. A typical man trolley is represented in Figure 8, which shows the trolley of a 15 ton bridge where a two line bucket is used. Two rope ends are anchored on the trolley frame so that only one closing drum and one holding drum are required. One drum is keyed directly to the shaft, while the other drum runs on a quill carried on the same shaft. Each drum is driven by a separate motor through a single gear reduction with the gears enclosed in oiltight cases and running in oil. The brakes in this case are located between the motor and the pinion. The travel motors are supported on cradles which are attached to the axles of the trolley and permit the rotation of the driving pinions about the gears, which are keyed to the axles, thus providing proper engagement of teeth and compensating for the movement between the motors, which are mounted on the trolley frame, and the axles, since the suspension is of the spring type permitting considerable vertical movement between the axles and the trolley frame. This type of modern trolley incorporates non-friction bearings throughout with the selection of bearings determined by a combination of the load on the bearing and the total number of expected hours of service. The trolley wheels are usually of the rolled steel, rim tough-

ened type, although some owners prefer to use a cast steel center with tool steel rims shrunk into place. The same prefernece for rolled steel, rim toughened wheels in the trucks of the bridge is becoming increasingly manifest, although some operators still place their faith in cast iron wheels; but we believe that this is more a local prefernece than the universal choice today. Where it is necessary to rotate the bucket through a 90 degree arc as is usually done in unloading boats, due to the fact that the length of hatch is transverse to the ship, various means have been provided for this rotation. On the bridge illustrated in Figure 2, this rotation is secured by introducing a small turntable below the hoist drum and anchoring two rope ends to the turn table. The rotation of the turntable through an arc of 180 degrees provides a 90 degree rotation of the bucket without the use of any deflecting sheaves. This construction entails the use of a two line bucket with the rope running through the bucket during hoisting and may prove objectionable to some operators, as there is considerable difference of opinion as to whether or not this type of construction is detrimental to rope life. Since the average operator does not keep accurate data on rope replacement, it has been exceedingly difficult to get a true picture of rope life and a proper comparison between fleet through and non-fleet through buckets. In this connection, however, it has been developed that the use of more flexible cable, which is rapidly replacing the old standard 6 x 19 wire ropes, does give considerable additional life, and in many installations the more flexible types of wire rope are being adopted with considerable success.

Safety requirements dictate that the operator's compartment should be separated from the control room, as shown in Figure 9, and fully insulated against fire risk. Clear vision is of great importance, and this is obtained by carrying the windows entirely to the floor and considerably improved by sloping the windows inwards as they approach the floor level. Sufficient space should be provided on the trolley for all electrical installations, and maintenance will be facilitated if ready access is made available to all parts of the switchboard, resistances, etc.

Figure 9—The operator's compartment should be separated from the control room, and insulated against fire.

SAFETY FEATURES

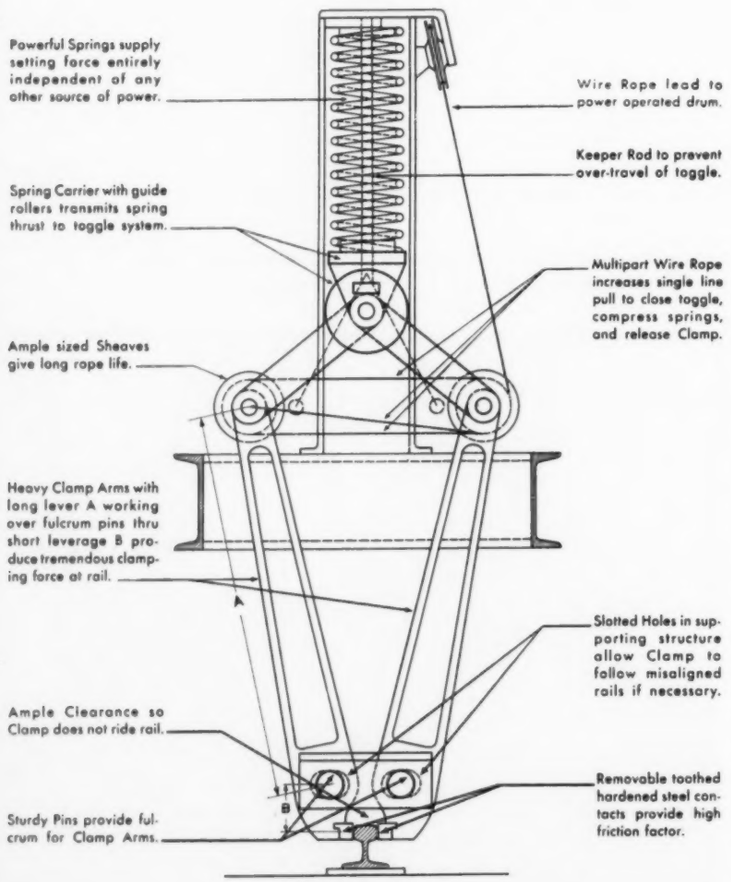
Numerous safety features, such as rail clamps, trolley bumpers, skew limit switches, anemometers, and lift boom latches are incorporated in the modern bridge, and the most important among these is the rail clamp installation.

A rail clamp installation should operate quite independently of the willful desire of a bridge operator. The modern types of acceptable clamps are usually tied in with the bridge travel controller so that the clamps automatically set when bridge travel ceases and release just before travel begins. In case of current failure, the clamps are self-setting either by the action of springs or weights and entirely independent of the electrical circuits. A typical clamp installation is shown in the photograph in Figure 10 and also in greater detail in the sketch in Figure 11. This clamp is spring set and motor released, and as you will note from Figure 11, is of very simple construction with no adjustable parts to get out of order. The only replaceable part is the

Figure 10—Rail clamps are an important safety feature, and should set automatically when bridge travel stops.

toothed insert which engages the rail, and several such installations have required no repair after ten years of usage except a resharpening of the teeth. This clamp can be figured for a definite horizontal resistance as the strength of the compression springs can be varied to meet different pressure conditions. There is one weakness in the present testing of such rail clamps which should be given careful consideration. Clamps are usually tested one at a time by energizing the travel drive with the clamps set and often up to the full horsepower of the travel motors. This is, as far as it goes, a fair method of testing, but does not subject the clamps to as great a force as they are subjected to under extreme wind stresses. It is doubtful whether any bridge installation has travel motors of sufficient size to drive the bridge against a wind of 100 mph. velocity, but we are still content to test clamps with the travel motors without realizing that we are not giving them a test which is equivalent to the actual conditions against which they must hold. A more positive method of testing would be the use of a piece of testing equipment which would clamp to the rails and exert a definitely measured thrust against the truck of the bridge, which could be increased to a magnitude equal to, or somewhat greater than, the actual thrust which would be calculated to be exerted at the maximum wind velocities considered as a basis of design. In figuring wind stresses, there is also too much faith placed in the common practice that wind stresses are of a static nature, whereas they must be considered more as of a dynamic nature. In storms which have occurred in the Great Lakes district within the past year, anemometer records have shown where wind velocities have increased as much as 50 mph. within a space of two minutes and have fluctuated from 50 up to 80 mph. for a period of an hour or two, which would indicate that not only are dynamic stresses involved, but they are also subject to wide variation over a considerable time period. This sudden application of load dictates the type of clamps which will respond rapidly and which, when tied in with an anemometer, will produce positive results and will be entirely independent of manual operation.

Figure 11—This rail clamp is spring set and motor released, and contains no adjustable parts to get out of order.


Powerful Springs supply setting force entirely independent of any other source of power.
Wire Rope lead to power operated drum.
Keeper Rod to prevent over-travel of toggle.
Spring Carrier with guide rollers transmits spring thrust to toggle system.
Multipart Wire Rope increases single line pull to close toggle, compress springs, and release Clamp.
Ample sized Sheaves give long rope life.
Heavy Clamp Arms with long lever A working over fulcrum pins thru short leverage B produce tremendous clamping force at rail.
A
Slotted Holes in supporting structure allow Clamp to follow misaligned rails if necessary.
Ample Clearance so Clamp does not ride rail.
Removable toothed hardened steel contacts provide high friction factor.
B
Sturdy Pins provide fulcrum for Clamp Arms.

Various types of trolley bumpers have been used, particularly the swinging beam clamp type which engages the wheels of the trolley, and the spring box type which engages the trolley frame. Of these two, the spring box type requires less adjustment; and since it engages the frame work of the trolley, it does not cause any direct shock to the wheels, axles, and bearings. In any type of bumper the design should provide for the safe stopping of the trolley at full speed without damage to either the trolley or the bridge structure. While dead man switches are usually provided in case of a physical failure of the operator, they are not always a positive means of control; and usually if a trolley hits the bumper, it is going at full speed and provision should be made for this impact.

Anemometers are a very necessary safety factor and are provided on all modern equipment and arranged to prevent bridge travel and skewing at a predetermined wind velocity, which is usually 35 mph. The anemometer installation is subject to considerable discussion as to whether the operator should have a by-pass to enable him to make short runs in the face of high wind velocity; but when one considers the records which have been listed in recent storms, this is a doubtful procedure and there should be a definite interlock with the controls so that the bridge must remain inoperative as far as traveling is concerned when the anemometer has reached its customary cut out limit.

WELDING OF ORE BRIDGES

The only reference made to welding in this paper has been in connection with repair work. The rapid advance in welding in many lines of construction has been accompanied with numerous benefits both to the manufacturer and to the user, and these benefits should be extended to the ore bridge field. The reaction of many operators to the suggestion that ore bridges be of all-welded construction is usually one of surprise without realizing that they do not hesitate to use welding wherever repairs are necessary. So far, no ore bridge has been welded, but this is largely due to the fact that very few bridges have been built in recent years and partly due to the fact that several bridges now under con-

Figure 12—This large traveling gantry crane, used in a ship yard, is of all-welded construction.

struction are being built by manufacturers who have not had occasion to engage in welded construction to a great degree.

The welding of an ore bridge does not offer any difficult problem, and we do not believe that it would complicate the erection to any great extent. A very considerable amount of welding is being done in connection with the National Defense Program in the furnishing of all-welded cranes, many of which offer problems in welding and in design of members for welding which are far more difficult than any problem which will ever be encountered in the simple truss structure of an ore bridge. To illustrate the type of structure to which we make reference, we are showing in Figure 12 a traveling gantry crane of large proportions, unusual design, and all-welded construction throughout. This crane is one of ten which is being built in one of the Eastern shipyards and had a precedent in that two cranes of similar, but smaller, construction were being built two years ago.

This crane, with a capacity of 28 tons on the main hook at a radius of 85 ft., has a boom of triangular cross section with an overall length from boom pin to boom tip of 150 ft. The top chord consists of a single I beam member with the splices designed as butt splices without reinforcement. All structural parts of the crane consist of structural grade low carbon steel with the exception of the three chord members of the boom, where low alloy steel was used to save weight. Several of these cranes are already in operation and are giving excellent service. In addition to testing these cranes at the rated loading where the 28 ton load was raised on the main hook at 85 ft. radius and allowed to drop at a speed of 190 ft. per min. and caught in mid-air, an overload test of 25 per cent was made under similar conditions without damage to the welded structure. This crane is cited only as an example of what has been done in the way of welding mechanical equipment, and the development of designs of ore bridges of all welded construction is immediately at hand and will yield visible returns to the purchaser, possibly not in lower initial cost, but certainly in maintenance. In ship construction the swing-over from the all riveted ship to the all welded ship has been amazingly rapid, and this swing-over has been accompanied with a tremendous reduction in maintenance costs.

The introduction of welding into ore bridge and similar equipment will doubtless be accompanied by the introduction of the use of low alloy steels. It is advisable that the designers and the purchasers of such equipment give full consideration to the problem involved, as we believe that progress is made faster when sufficient time is taken for full realization of the problems involved. There is a tendency to go to low alloy steel, and this tendency will increase as better low alloys are developed. The designer and purchaser should both keep in mind the fact that lightweight construction is not always the proper answer to their problems and that in structures subject to dynamic loading, a certain amount of minimum weight is necessary for proper rigidity in the structure. The introduction of welding will provide greater rigidity in the joints and will permit to some degree the introduction of lighter sections in the structure, but the effect of too great a reduction in the stability of the structure should not be encouraged for the sake of economy only, and enough steel should be left to provide that degree of rigidity below which it is not safe to go.

DISCUSSION

PRESENTED BY

JAMES FARRINGTON, *Superintendent*, Electrical Department, Wheeling Steel Corporation, Steubenville, Ohio

G. F. WOLFE, Engineering Works Division, Dravo Corporation, Pittsburgh, Pennsylvania

A. E. GIBSON, *President*, Wellman Engineering Company, Cleveland, Ohio

THOMAS E. HUGHES, *Superintendent of Maintenance*, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania

JAMES FARRINGTON: I think the introduction of the worm drive on the bridge is an excellent one, as it gets away from many of the troubles we have had on the spur gearing. In regard to the maintenance of the structural work on the bridge, we make it a point in the dull season to go over the joints that are subject to the greatest stress and if we find any loose rivets we take them out and ream the holes and drive new rivets.

In testing the clamps, we use compressed air on the anemometer to bring it up to the predetermined speed, in order to test the clamps electrically as well as

mechanically. When the bridge is not in operation, we use steel cable, anchored to the structural work, realizing that the clamps will not hold the bridge in a heavy windstorm.

I would like to ask Mr. Wolfe if, in his opinion, it is worth while to streamline the main structural work to cut down the stress sidewise.

G. F. WOLFE: I will answer that question in part. It is not necessary to streamline in order to make the bridge hold, because clamps are developed that will hold the bridge against any predetermined velocity. It is unfortunate that clamps have not been given proper attention until today.

When the bridges become welded, they will naturally lend themselves to streamlining because we will reduce the wind area of the sections and practically eliminate all the gusset plates so that the all-welded bridge will streamline itself considerably.

A. E. GIBSON: I would like to make a few comments based on our experience with worm drives. We have just completed the mechanical work on two 23-ton bridges for the Chicago district and we are now erecting a 15-ton bridge in Buffalo. All of the bridges are entirely worm driven: bridge travel, trolley travel and hoist and hold drum operation. In addition we are also now erecting a 7½-ton bridge in Nova Scotia in which the bridge travel is worm operated.

In the Chicago bridges, in which we designed and fabricated the mechanical details, there is an unique arrangement of worm driven trucks new to the industry. The mechanism consists of 16 worm driven wheels at each corner of the bridge, a total of 64 wheels supporting the structure. Each set of 8 driven axles is operated through a motor and a two-reduction welded gear case having hardened tooth gears. To this gear case are coupled two driving shafts each of which drive four of the eight worms. With exact tread diameters on all wheels, the driving effort is thus uniform throughout. Each axle, as stated above, is individually motor driven, the worm wheel being keyed to the axle with the worm being mounted in the case above the axle. The driving shaft is continuous, being coupled to the worms.

The 15-ton bridge for Buffalo and the 7½-ton bridge for Nova Scotia are of different design, having driven axles with double wheels at each corner of the tower and eight driven axles with single wheels at each corner of the shear leg. Double equalizers are utilized in this design, giving a flexibility particularly advantageous with inequalities in the track.

The trolley design is also novel in that five axles, ten wheels, support the trolley. Four of the five axles are motor driven, the fifth one, which is an idler, is over the cab. As in the truck design, the trolley travel has the worm wheel keyed to the axle and each axle is individually motor driven. The trolley proper is not cluttered with mechanical equipment as the hold and hoist units are mounted on a sub structure between the trolley and the cab.

We have gone all the way in endeavoring to incorporate into the mechanical equipment the best obtainable in materials. The worms are anti-friction bearing mounted, shafts of alloy steel. The drum and sheave shafts are carburized and ground. All spur gears were flame hardened and pinions are of hardened tool steel. The trend, particularly in the steel industry of late years has been to obtain more rugged mechanical equipment of a design to keep repairs to a minimum. Certainly men in that industry know what breakdowns mean just when you need the equipment the most. There is a tendency sometimes to go too far. For instance, Mr. Wolfe's company and ours are now having the same experience with the Navy, who are demanding 30,000 hour life in roller bearings, a specification the roller bearing manufacturers refuse to quote on.

I would like to comment briefly on the subject of welding. All of us know the very splendid job Mr. Wolfe's company has done on welded construction, but that does not mean that everyone can build a satisfactorily welded bridge. There is a great deal of technique to be learned in making satisfactory welds. I have seen many failures in welds and have traced back many failures and found that in almost every case it is a question of technique. We have been building all welded, low-alloy clamshell buckets for a number of years. We went into that because of breakage experienced with castings. We found we were able to decrease the weight very materially. For instance, we have in the Buffalo district a coal bucket handling eight tons of coal built at the same weight its predecessor had that handled six tons. We have 15-ton capacity welded buckets in the Chicago district of the low-alloy welded construction that are handling a great deal more tonnage than the old cast buckets.

There is a lot of technique in welding low-alloy steels. There have been innumerable failures in trying to weld it the same as welding low-carbon steel. It just cannot be done the same way. One cannot take a cold, air-hardening material and slap a lot of weld on without having a good many stresses set up that will probably be fatal. Then again there is the technique of preventing undercuts. Many failures have occurred not in the weld but in the little undercut where the fillet of the weld joins the plate. Ever so slight an undercut reduces the section, and there, concentrated stresses are built up in the nature of six to ten times the stress in the adjacent metal.

I would like to comment also on the subject of riveting of low-alloy steels. There has been a lot of trouble in this, mostly because it is necessary, in order to develop the strength of the sections of steel, to use high tensile rivets. When someone develops a high strength rivet of eighty thousand pound shear, as ductile as the soft steel rivets we use now, that will be the millennium. But there isn't any such material. There are many analyses of high strength rivets used, but most of us, I think, are using 1½ per cent manganese, 30 carbon Government specification on high tensile rivets. It is a very tricky material to drive. Our time of driving high tensile rivets probably runs from 50 to 75 per cent more than with low tensile rivets. It is our practice to keep the gun or bull riveter on high strength rivets until they are sufficiently cooled to build the structural strength back into it, otherwise the head is very liable to pop off.

I have seen many such rivets driven in the shop which evidently were all right, only to come in in the morning and find the heads on the floor. We ran into that in our

(*Please turn to page 70.*)

Performance of CUTTING TOOLS

By L. J. St. Clair

President

GENERAL TOOL & DIE CORP.

East Orange, New Jersey

Presented before A.I.S.E.
PHILADELPHIA DISTRICT SECTION

▲ A CUTTING TOOL'S ability to cut depends primarily on three qualities: room temperature hardness, "red" or operating hardness, and toughness. No cutting tool, so far developed, possesses all three qualities to a high degree. Some types of cutting tools possess one of these three qualities to a superlative degree and are deficient in the other two. The carbon steel tool is a good example of this type. It possesses a great deal of toughness, but lacks room temperature hardness and "red" hardness. Other types of tools possess two of these three qualities to a high degree and lack or are deficient in the third quality. The diamond tool is a good example of a tool possessing two of the important qualities, namely, room temperature hardness and "red" or operating hardness, but is sadly deficient in toughness. This lack of toughness in the diamond tool precludes its use on most cutting jobs.

To use good judgment in choosing a cutting tool for a given job, one must appreciate and understand the various types of cutting tools now popularly in use. These types or kinds of cutting tools can be listed as follows:

1. Diamond tools.
2. Carbon tool steel tools.
3. 18-4-1 high speed steel tools.
4. Cobalt high speed steel tools. (These are called low and high cobalt high speed steel tools depending on the percentage of cobalt in them.)
5. Carbide tools.
6. Cobalt, chromium, tungsten cast tools. (Due to the length of their designation, we will call these henceforth by the name of cast tools.)

To use good judgment, one must also know what qualities each type of tool possesses to a high degree and what quality or qualities are lacking in each type. Let us therefore analyze each type of cutting tool with respect to the three necessary qualities already mentioned. First, let us analyze each type of tool with respect to room temperature hardness. Listing these tools from the hardest to the softest, they would appear as given in Table I.

	Rockwell C hardness
1. Diamond tools (hardest)	Unknown
2. Carbide tools	72 to 78
3. Carbon tool steel tools	65 to 67
4. Cobalt high speed steel tools	64 to 66
5. 18-4-1 high speed steel tools	63 to 65
6. Cobalt, chromium, tungsten cast tools	61 to 63

If room temperature hardness were the only important quality a cutting would need, your choice of tool would be simple. You could choose the diamond tool for most jobs. Many users of tools appear to think that room temperature hardness is the one thing to think about, but this is far from being so. You all know that due to lack of toughness, the diamond or carbide tools are failures on most cutting operations that are severe.

Let us now list each type of tool with regard to their "red" hardness or operating hardness. The term "red" hardness is popularly used to denote operating hardness of a cutting tool. When taking a heavy cut on tough alloys high enough temperatures are produced to cause the end of the tool directly under the cut to become red hot. Hence the term "red hardness" when applied to a cutting tool means its hardness under operating conditions. The "red" hardness table for the various types of tools based on the approximate hardness of the cutting tool at 1000 degrees F. (a temperature often exceeded while cutting tough metals), is as shown in Table II.

Type of tool	Approximate Rockwell C hardness at 1000 degrees F.
1. Diamond tools (hardest)	Unknown
2. Carbide tools	68 to 72
3. Cast tools	54 to 56
4. Cobalt high speed steel tools	40 to 48
5. 18-4-1 high speed steel tools	35 to 37
6. Carbon tool steel tools	18 to 20

You will notice that in this tabulation, the diamond tool and the carbide tool retain the same position as in Table I. The cast tools jump from last position on Table I to third position on Table II, while the carbon steel tools drop from third position in Table I to sixth position in Table II. This readily explains why, on many operations involving high heat, the carbon tool steel tool is definitely out of the picture as a cutting tool. It lacks "red" hardness and becomes too soft to act as a cutting tool on jobs that produce high heats.

Were room temperature hardness and "red" hardness the only two qualities a cutting tool would need, again the choice would be an easy one. The diamond tool would be first choice and the carbide tool would be the second choice since both of these types of tools are in the first and second position in Tables I and II. We all know that the choice is not that simple because of the lack of toughness in both of these types of tools. There-

fore, let us list the last of the three qualities which are required, namely toughness (Table III).

Type of tool

1. 18-4-1 high speed steel tools (toughest).
2. Carbon tool steel tools.
3. Cobalt high speed steel tools.
4. Cast tools.
5. Carbide tools.
6. Diamond tools.

Note: The cast tools are not quite as tough as the low cobalt high speed steel tools (4 to 8 per cent cobalt) but are tougher than the high cobalt high speed steel tools (10 to 12 per cent cobalt).

As a general statement, I believe it is correct to state that toughness is usually the most important quality a cutting tool should have on a great majority of cutting operations. This is absolutely true on heavy work and also true on all tools that require torsional strength, such as end mills, drills, etc. Sometimes a tool which lacks toughness under ordinary treatment can be made to operate successfully by a simple trick. On roughing cuts, the cutting edge of a tool is hardly used as a cutting edge, since the chip often impinges on the face of the tool $\frac{1}{16}$ to $\frac{1}{8}$ in. away from the cutting edge. The cutting tool under such conditions really acts as a wedging device only. Since the cutting edge under these conditions does not serve any real function, it can be "dubbed" off without interfering with the tool's cutting ability. By stoning off the keen edge of the tool, you greatly strengthen the cutting edge area, and prevent the chipping of the cutting edge due to hard spots or hard pieces of scale, or inclusions hitting the cutting edge. When the cutting edge is chipped, side wear on the tool is greatly hastened and results in early failure. You can stone a land at 30 to 50 degrees to the cutting face of the tool. The width of the stoned land can be from 15 to 25 per cent of the feed per revolution with excellent results. This "trick" will make a tool that usually is not tough enough, appear to have sufficient toughness.

I believe the next most important quality in most cutting operations is "red" or operating hardness, and that room temperature hardness is usually the least important of the three qualities when considering general machining operations. It will be well to combine Tables I, II, and III into one table to get a clear picture how each type of tool compares with the other types.

Type of tool	Respective standing,		
	Room temperature hardness	Operating hardness	Toughness
Diamond tools	1st	1st	6th
Carbide tools	2nd	2nd	5th
Carbon steel tools	3rd	6th	2nd
Cobalt H.S.S. tools	4th	4th	3rd
18-4-1 H.S.S. tools	5th	5th	1st
Cast tools	6th	3rd	4th

Now that we have tabulated the various types of tools as to their respective standing in each of the three qualities required in a cutting tool, how can we use the information to advantage?

This you can do by analyzing the job to be machined with respect to: (1) the tensile strength of the material to be cut; (2) the size of the cut to be taken.

The tensile strength of the material to be cut will determine the choice of tool in many cases. If the tensile strength is low, such as rubber, bakelite, etc., you do not require toughness in a cutting tool. Generally when machining low tensile strength materials, very little heat is generated, hence you do not require "red" hardness. The tools as listed in Table I would be the best tools to use in the order listed. If the tensile strength of the material to be machined is high such as in 52100 or 6250 types, and other tough alloy steels, a great deal of heat is generated, and a tough tool is often required, hence you would choose tools as listed in Table III, considering them in the light of the listing in Table II. Table III listing would hold as such on very heavy cuts, while the order listed would change somewhat on light and finish work where "red" hardness along with a fair degree of toughness would be indicated as the best choice.

The size of the cut being taken will influence the choice of tools. Generally on low tensile strength materials, the Table I listing would stand as is except for the diamond tool. Heavy cuts on such materials would preclude the use of the diamond tool because of its high cost and lack of toughness. Carbide tools would usually be the best choice. Table II and III listings would be most important on all cuts on high tensile strength materials; Table I listing would be the best choice on light and semi-finish cuts, since "red" hardness would be required most, and Table III listing would be best on heavy cuts, because toughness of the cutting tools would be needed most.

Now that we have studied the various types of tools as to the three important qualities, let us take a few cases of machining and make a proper choice of type of tool:

1. *A light cut on bakelite.* Bakelite has a low tensile strength and generates but little heat while being machined. In this case, room temperature hardness is the most important quality. A diamond tool is the first choice if a simple tool is required, while a carbide tool would be best if a form tool or large tool would be needed due to the prohibitive cost of a diamond form tool.

2. *A light roughing cut on cast iron using $\frac{1}{32}$ in. feed and $\frac{3}{16}$ in. depth of cut.* Cast iron has a comparatively low tensile strength but generates much heat while being cut. The most economical tool here would be a carbide tool (Table II) due to the high surface feet possible with carbide tools on iron. The toughness of the carbide tool would be sufficient for this job. In case machine conditions would not allow the use of a carbide tool, then the next best choice would be a cast tool (see Table II).

3. *A medium roughing cut on a type 52100 forging using $\frac{1}{32}$ in. feed and $\frac{3}{8}$ in. depth of cut.* This material has a very high tensile strength, and generates much heat while being machined. The best choice here would be a cast tool since this type of tool would have sufficient toughness along with a good "red" hardness. Second choice would be cobalt H.S.S. (see Table II). The

diamond tool and the carbide tools would be too weak to do such work properly.

4. *A heavy roughing cut on a 3140 forging using 1/16 in. feed and 1/2 in. depth of cut.* A cast tool would be best here on steady cuts, due to the good balance of toughness and red hardness existing in this type of tool. On a jump cut, 18-4-1 H.S.S. would be usually required because of the severe blows produced on a tool by such a tough alloy steel.

5. *A roughing cut on a .20 carbon steel casting using 1/16 in. feed and 1/2 in. depth of cut.* Usually the cast tool would be most economical because of its high "red" hardness, causing it to stand up better than H.S.S. on the sand and hard spots usually encountered in castings. (H.S.S. being much softer under such a cut, would wear more rapidly.)

6. *A heavy roughing cut on a planer on tough alloy steel forgings or castings using 1/8 in. feed and 3/4 in. depth of cut.* In these cases, toughness is most important and 18-4-1 H.S.S. is the best choice (see Table III). A cast tool generally would not be strong enough and would probably be impractical due to edge chipping.

These few examples show how simple it is to make an intelligent choice of type of tool providing one knows the inherent qualities of each type of tool. Hence when a machining problem is involved, consider the qualities required in a cutting tool to best do the job, and then choose the type of tool that has these qualities in best balance and to the highest degree. Your choice of tool should be the most economical one to use.

DISCUSSION

PRESENTED BY

L. F. COFFIN, *Superintendent,* Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland

LOUIS MOSES, *Superintendent,* Rail Mill and Roll Department, Bethlehem Steel Company, Sparrows Point, Maryland

L. J. ST. CLAIR, *President,* General Roll and Die Corporation, East Orange, New Jersey

H. E. SNEED, Engineering Department, De Walt Products Corporation, Lancaster, Pennsylvania

STEVE KNAPP, *General Foreman,* Machine Shops, Bethlehem Steel Company, Sparrows Point, Maryland

L. F. COFFIN: There is a lot of food for thought in this apparently very simple exposition. It is apparent that probably in a great majority of machine shops in the country, the real value of tools for the particular jobs they are to do is not sufficiently studied, and that the productive capacity of this country for machine work would be stepped up considerably by a first class tool study man in each shop.

LOUIS MOSES: I would ask Mr. St. Clair to expand his remarks with reference to tools subjected to intermittent shock such as are used on shapers, gear cutters and milling cutters.

L. J. ST. CLAIR: You remember, when I gave the third example—a heavy feed and a steady cut, I said the cast type of tool was the best tool for this work. For a jump cut, the 18-4-1 H.S.S. tool is the best tool. Now when it comes to planer work on the high tensile strength steel, 18-4-1 H.S.S. is the best, because in this case toughness is required most. When it comes to cast iron you can get a carbide tool to function on a planer, if you dub off its cutting edge. We have some big cast tools working on low carbon castings, such as 20-carbon castings. These will not work on a chromium-vanadium casting, though. Such work is beyond the toughness of the cast tool.

When it comes to milling, we have a different situation; the load per tooth is light. We go up to as much as .020 in. feed per tooth, which cannot be considered a heavy toothload. At a certain aircraft factory they have done some of the most remarkable milling work on the aircraft steels with the cast tools, and with remarkable results; many times what an ordinary H.S.S. blade would do. I have stated that we must first think of a job from the tensile strength standpoint, and second, the size of cut—so you see, the size of the cut changes the picture. A big heavy feed requires more toughness in a tool and vice-versa.

H. E. SNEED: Our cutting has largely been on nickel-molybdenum cast iron, and the carbide type is the best tool that we have found for our purpose.

STEVE KNAPP: Mr. St. Clair and I have had a lot of dealings pro and con. He knows our job in the shop. He has been with us and has talked things over, and I have been to his school and I have enjoyed his talks—but I notice something here with the stainless steel and the manganese steel. Would you put chromium steel and monel in that same class?

L. J. ST. CLAIR: Monel machining is one of those borderline jobs. I believe I have fooled away more time trying to cut monel metal than any other metal. Carbide tools are poor on a number of monel specifications. There are a few cases where they work pretty well. I would advise this, however: The next time you have a monel metal job, you can probably lick it nicely with a cast tool. To my mind monel metal is worse than stainless for clinging to the cutting edge. You have got to have a keen edge—a very keen edge. I don't believe the carbide tool edge, in the keen condition, is strong enough for monel; it chips off and breaks. The cast tool, with its greater toughness, often works much better than any other type on monel.

We have often thought that, on aluminum alloys, the carbide tool was the best to use, yet I have a number of companies telling me they are using a much softer tool. This has surprised me, for I never anticipated such a result. Again in the case of monel metal, with the brief experience I have had with the cast tools, they are the best answer.

STEVE KNAPP: For the general purpose use, you would recommend 18-4-1 H.S.S. on heavy interrupted cuts and a softer tool on the steady cuts.

L. J. ST. CLAIR: That is a correct analysis.

STEVE KNAPP: On cast steel, what tool would you recommend?

L. J. ST. CLAIR: The type of tool depends on the size of the cut, but I think generally the cast tool would

(*Please turn to page 70.*)

OPERATING PROBLEMS *in* BAR MILLS

By W. H. Bennett, Superintendent

GAUTIER WORKS

BETHLEHEM STEEL CO.

Johnstown, Penna.

Presented before A. I. S. E.
SPRING CONFERENCE, Youngstown, Ohio

▲ MUCH has been said and written about the design of merchant mills and bar mills. Extensive studies have been made of equipment; size and type of heating furnaces; location, size and speed of rolls; type and size of motors for roll drives; and the different constructions of the cooling beds employed. However, little has been written about the everyday problems confronting the mill operator, in connection with the conversion of various grades and sizes of billets into steel bars of all classifications. These problems include heating, rolling, shearing, straightening, bundling and labeling for shipment.

In spite of all improvements in equipment, the human element still plays a major part in keeping the various operations properly coördinated. This article has been prepared for the purpose of reviewing the more important factors, in the hope that someone may feel the urge to relate how he has solved problems which, as yet, may remain a puzzle to many other mill operators.

A merchant mill is operated for the sole purpose of rolling steel products for customers' orders. This operation must be carried out in a manner that will insure satisfaction to the cutomer and profit to the mill owner. In this work the operator is confronted by many problems, and his job rarely has a dull moment.

Let us follow an order in its journey from the sales department through the various operations until the finished product is loaded for shipment.

An order generally specified the following items: quantity; grade; size; weight; length, if straight bars, or size and weight, if coils; tolerances; special requirements; shipping date desired; railroad routing; type or size of car; size of lifts or bundles; method of covering and blocking.

From the sales department the order passes along to the order department where it is entered on the standard form, giving every requirement in the proper space alloted to it. This speeds up the entry and expedites the checking and filling of the order. The standard form contains all data given in the customer's order and specifies any additional information supplied by the metallurgical department.

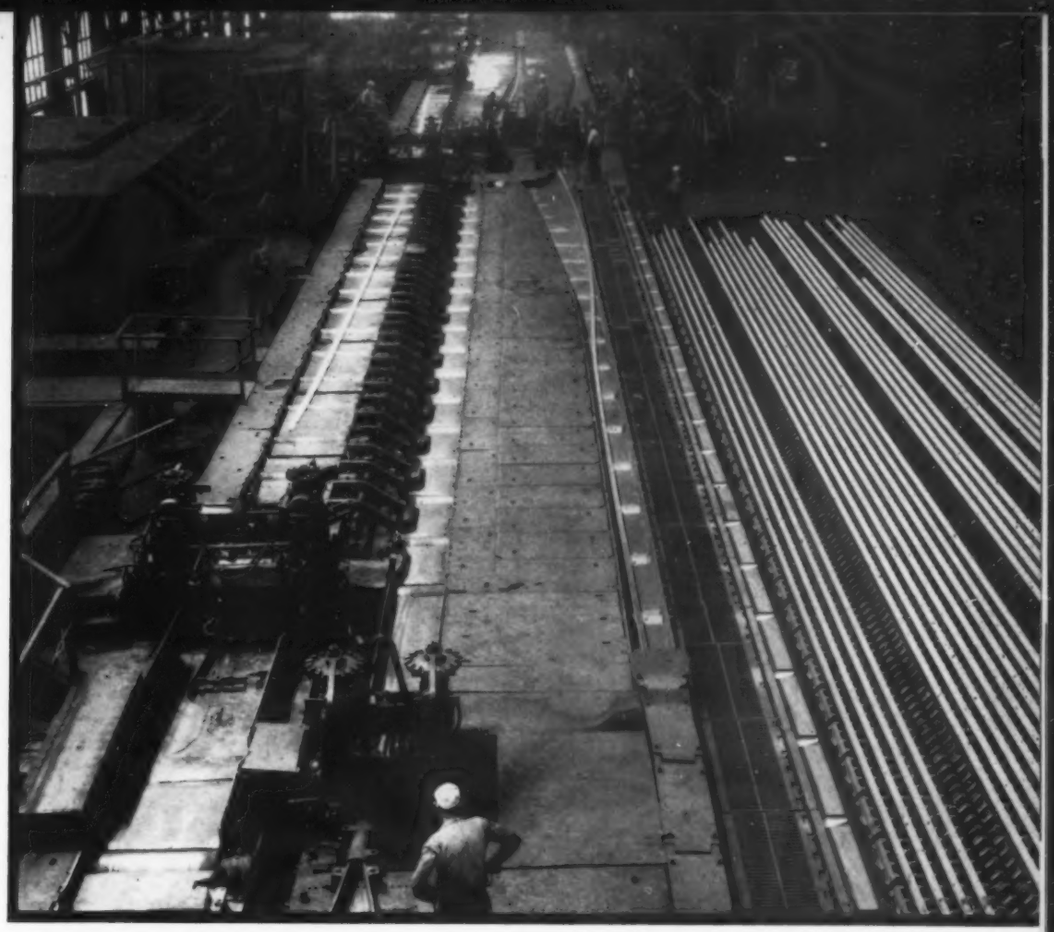
The metallurgical department acts as a clearing house. Here the order, now on the standard mill form, is checked for chemical requirements, physical properties, tolerance limitations, decarburization limits, and other special requirements. From records kept in this department, such as the ultimate use of the material ordered, billet preparation needed, performance of material previously shipped on similar orders, and from general knowledge of what is necessary to satisfy the customer, additional instructions are placed on the order to guide everybody concerned.

Frequently the metallurgical department requests additional information from the customer. In cases where the customer has included specifications which entail much extra work, but which are of little or no value to him, he may be prevailed upon to waive or change the requirements. This is a case where the metallurgical department can render real service to the mill, while still seeing that the customer receives a product that is satisfactory in every respect.

As soon as all the necessary instructions about filling an order have been entered on the form, it is generally returned to the order department. Here it is turned over to the steel provider who supplies the following information: number, weight and size of billets required; grade of steel; degree of billet preparation; time allowed to meet the bar mill schedule.

Weight of the billets must be chosen without leaving too much scrap or excess finished weight. The weight selected varies according to the difficulties anticipated in rolling the size or shape involved; whether other orders of the same size are to be filled; number of tests required; lengths desired; whether dead lengths or variable lengths are specified.

Lately much consideration has been given to the lengths specified on bar orders. For the benefit of those not familiar with this problem the following explanation may be of interest. If the customer requires, say 10,000 ft. of a certain size of bar, he may order five hundred pieces, each 20 ft. long. When a considerable number of dead length bars are desired, a special weight billet should be ordered to avoid excessive crop ends. To make sure that each billet will cut into bars of even 20 ft. lengths the steel provider has to order a definite excess weight, depending upon size and other conditions, in addition to the weight of the finished bars. Should



After bars are delivered from the mill the important factor in maintaining their straightness is the hot bed, which must be kept in good condition.

the customer be willing to take 18 to 20 ft. lengths, the same footage can be furnished by ordering billets of smaller excess weight over and above the finished weight required. In many cases the customer cuts his bars into very short lengths and orders 20 ft. bars only for convenience in storing and handling. This may mean a difference of several per cent in yield to the mill rolling the bars.

The steel provider must accumulate enough orders of a particular grade of steel to take the product of an entire heat. This heat may be cut into billets for immediate use, or for future orders to be rolled later. For a bar mill rolling a wide range of sizes it may be necessary to roll this one heat into several billets of varying sizes and cut these into a number of different weights.

Lacking sufficient orders to take an entire heat, the steel provider must decide whether to bank the balance of the heat in ingot form or to roll it into definite size billets. In making the decision he draws upon past experience with the particular grade of steel involved.

In most bar mills the best practice, from an economy point of view, is to group all orders of the same size, regardless of the grade. When making 1 to 3 in. rounds, for instance, rolling is started with the 1 in. size, going up through all sizes, or with the 3 in. rounds, going down.

To illustrate let us start with $1\frac{1}{16}$ in. rounds, assuming a total of 150 tons of this size to roll, to be made up of seven different grades of steel. This will require from five to ten hours, depending upon the capacity of the bar mill. Before the billets can be charged into the furnace, part of at least seven different heats of steel must be available in the billet yard.

The billet mill generally rolls full heats, whereas the bar mill rolls one size from many heats. This means that there must be sufficient time allowed for the accumulation of various grades and sizes of billets for the bar mill, and sufficient billet yard capacity for storing the billets until they are charged into the bar mill furnace in the proper sequence.

What has been said for $1\frac{1}{16}$ in. rounds is also true for other sizes and shapes. Furthermore, the billets must be of proper weight in order to insure a fair yield on the bar mill, and to reduce the loss in crop ends. It is therefore necessary to use billets of different weights even though they all are rolled to the same size and shape.

BILLET PREPARATION

This operation includes chipping, scarfing, grinding, and straightening of the billets after scarfing. The billets must be prepared in proper sequence to meet bar mill schedules, and great care must be taken to preserve correct billet identification.

In most plants billets are prepared, chipped or scarfed at the blooming mill before they are transferred to the bar mill. When the billets are needed at the bar mill as soon as they leave the blooming mill, the scheduling of billet preparation becomes a problem. The blooming mill generally rolls an entire heat at one time, whereas the bar mill may roll the billets from one heat into a number of bar sizes over a period of from one to ten days. To get the billets to the bar mill in time for rolling, the chippers and scarfers may have to work on a number of heats at one time. Although this makes a

bad arrangement for the preparation department, it is nevertheless unavoidable if the bar mill is to be supplied with billets in the proper sequence.

With chippers and scarfers working on a number of heats at one time, the possibility of mixing the different grades is always present. Constant care is required to avoid this hazard.

Billets must be stocked clear of the mill and kept available for charging into the heating furnace in proper sequence. Heat numbers must be checked to make sure that wrong billets are not placed on the charging bed.

When the output of a mill calls for a large number of billet sizes, and a still greater number of weights for each billet size, it is necessary to have adequate billet yard space, in order that the different types may be segregated and made readily accessible for charging into the furnace. It is not uncommon to have six different sizes of billets, from fifteen to twenty different heats of steel, in twenty to thirty different weights at one time in a heating furnace holding 100 to 200 tons.

HEATING

Heat numbers and size and weight must be carefully checked before each billet is charged into the furnace. Copies of the orders for each grade are examined for heating requirements, and the furnace temperature and atmosphere are closely watched.

After the billet has been charged into the furnace the heater and the other furnace men must keep close watch in order not to lose track of it. From the copy of the rolling mill order the heater checks the grade of the steel. Guided by his own experience he follows any special instructions on the order. From time to time the combustion department checks and follows the heating of special orders. As several grades must be kept close together in the furnace the heater must exercise good judgment and take every precaution to see that the heating of one grade is carried out properly without detrimental effect upon different grades near by.

It is difficult to keep a close check on any single billet or a small group of billets after they have been charged into the furnace. The billets must be counted and marked as charged and carefully watched as they travel through the furnace. They are again counted as they are drawn from the furnace and the markers are checked. This double check is extremely important as miscount or a wrong reading of a marker means a case of mixed steel.

ROLLING

Rolling operations are governed by a number of factors such as layout of passes; draughts or reduction in each pass; grade or type of rolls; roll speed; type of roll bearing; roll neck lubrication; high pressure water for cleaning bars; purity of water; guides; billet temperature and finishing temperature; tolerances specified.

Much can be said about the proper layout of passes to produce the best bars, and this is one item which is constantly before the mill operator and the roll designer. Passes that are ideal on one mill cannot always be used on another mill making the same product, due to the effect of fixed roll speeds, spacing between roll stands, roll diameters, and other factors which may vary from mill to mill. Confronted with such a situation the mill operator and the roll designer must do what they can

The hot bed must be slow enough to allow the larger bars to cool, yet fast enough to deliver the smaller bars for hot shearing.

to change the shape or size of the pass, or the method of rolling, so that the steel will get the best possible working under the existing conditions.

One of the problems along this line has been the design of proper roughing passes to remove deep chipping and scarfing scars in the billets. This has been rather well taken care of in all mills, by various methods.

Roll makers have made great efforts during the past years to enable mills to produce more and better bars, and they deserve much of the credit for the remarkable progress achieved in this field.

Mill speeds are important. There is a decided advantage in using variable speed motor drives, especially where a mill is obliged to produce a wide variation of sizes and grades of steels, both of the bessemer and the open hearth variety.

Roll neck bearings also play an important part both from the standpoint of economy and efficiency. Some mill men claim that the greatest accuracy in size of rolled products is obtained by using roller bearings. This is disputed by others who advocate inclosed oil lubricated bearings, and also by users of composition bearings now marketed by some manufacturers. However, much of the accuracy in size obtained on some mills may be attributed to devices for holding rolls in close end adjustment. The turning of passes in finishing rolls, especially for rolling rounds, is extremely important if close tolerances are required.

It is essential that proper lubrication of roll necks be maintained at all times. The most neglected part of the mill is often the roll neck. Many of the older mills have practically no adequate provision for lubrication. This is particularly true for the middle roll on 3-high stands. The shortsighted policy of saving a few dollars' worth of grease per day by not keeping roll necks well lubricated will cost many times the amount in bearing wear and in off-size bars which have to be scrapped and remelted.

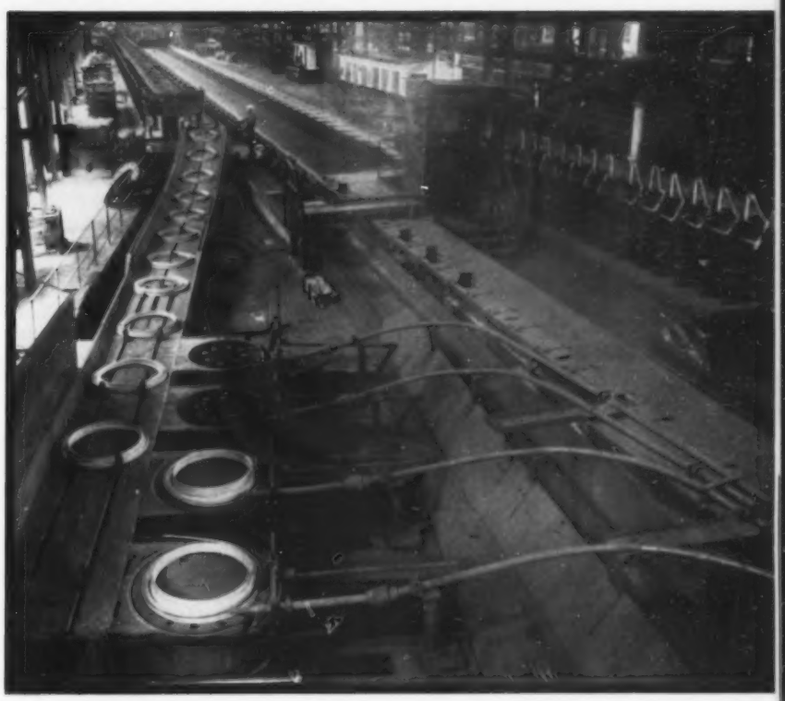
Present demands for bars with better surface have resulted in new mills equipped with high pressure water descaling systems. Older mills are now compelled to adopt such systems in order to produce bars with a surface comparable to that produced by the new mills.

To equip a mill with a descaling system requires a considerable capital expense. However, the insistent demand for bars with better surface will sooner or later force all mills supplying bars to the trade to go to such installations. Systems with a pressure of 1000 lb. per sq. in. at the spray nozzles have been very successful in producing clean surface bars.

In order to obtain high quality of bars it is important to have a good supply of clean water for cooling the rolls. A mill with a good water supply has a decided advantage over a mill which has no access to cold, clean water.

Without good guides it would be difficult to roll any sort of a bar. This refers both to entering guides and delivery guides. Poor guides produce scratches on the surface of the bars and often cause mill delays. A number of good guides have been placed on the market in later years. Roller guides, of which many are now in use, are still in the process of development and are constantly being improved.

Much progress has also been made in constructing billet heating furnaces that will give correct and uniform heating. With the modern equipment to guide and check the heater it is no longer necessary to rely entirely upon one man's judgment. Furnace men have shown a gratifying willingness to coöperate with the combustion engineers who, in installing scientific instruments, have brought about advances in heating and rolling practice which the mill man of years ago would not have believed possible.



From the rod mill, delivery may be made either to a hot bed or to coilers, depending on the nature of the product.

A modern heating furnace is equipped with the following instruments: fuel pressure regulator (gas or oil); automatic furnace pressure regulator; recording fuel pressure guage, showing pressure before and after regulator; indicating flow gauge showing fuel and air to burners; recording furnace pressure gauge; recording, indicating, and integrating fuel meter; recording pyrometer giving the temperature of the steel as it leaves the furnace.

The furnace men should be familiar with these instruments and should watch them constantly to keep a close check on the operation of the furnace.

Rolling tolerance is also a problem for the mill operator. No matter how close bars are held to size, the demand for closer tolerances is always being presented.

COOLING BEDS

After the bars have been delivered from the mill the next problem is to keep them straight while cooling. To accomplish this, various types of cooling beds have been designed, many of which are giving excellent service. However, no matter how good a cooling bed may be,

it requires close attention and must be kept in good repair to maintain proper alignment, so that the bars will be straight after cooling. Throughout the process of rolling and cooling every possible care must be exercised to properly identify every bar rolled.

Where a wide range of sizes is rolled, the selection of the proper cooling bed becomes a problem. It must be sufficiently slow (have enough notches) to hold large bars until they have cooled, and it must be fast enough to deliver small bars to the shears for hot shearing, as required by certain grades of steel. The bed should be designed for pack annealing if flat spring steel is one of the products of the mill.

Many of the larger bars of certain grades of carbon and alloy steel must be cooled more slowly than is possible on the ordinary cooling bed. In rolling these grades it is frequently the practice to remove the bars from the cooling bed while still quite hot and place them in a cooling furnace. The furnace, or pit, may be gas fired, or, in some cases, not fired at all. The bars are placed in the furnace which is closed tight to prevent circulation of air and escape of heat. In some cases the bars are removed from the mill hot and buried in ashes to retard the cooling.

SHEARING AND INSPECTION

The next problem is to cut the straight bars to proper length. For this purpose the shears available must be big enough to handle the largest bar and fast enough to shear the smallest sizes. Bars must be sheared with a tolerance that will satisfy the customer. The temperature of the bars delivered to the shears is governed by the size rolled and the speed of rolling and subsequent handling. Here the shear operator must draw upon his experience and allow enough extra length so that the bars will have the proper length when cold. Bars from the shears must be counted, weighed and assembled in lifts or bundles of the correct weight. For proper identification the bundles must be tagged and marked with heat number, size, length, weight, and customer. In some cases the individual bars are stamped and marked. Here special care must be taken to retain the identity of every bar before and after shearing. Special shear blades must be used for shapes and sections to prevent distortion during shearing.

Generally speaking, the inspection of the rolled bars begins right on the cooling bed. Bars that are not right are scrapped at the mill shears where they can be disposed of quickly and cheaply. Inspectors also gauge and inspect bars as they are being sheared, removing defective bars at this point. Sheared bars requiring still further inspection are taken away for bench inspection. Many of these bars may be found to have only slight imperfections and may be saved by some method of reconditioning, such as filing or grinding, or possibly by shearing down to a shorter length, cutting out the defective portion.

Sheared bars frequently go through still another operation, machine straightening. This is necessary where customers have specified machine straightened tolerance, or where the bars delivered from the cooling bed are not of commercial straightness. Many bars can be handled in some type of straightening machine, while others are of such a cross section that they can only be straightened in a gag press. This is an expensive operation which should be avoided wherever it is possible to use a roller straightener or some other straightening machine.

SHIPPING

Not many years ago shipping meant little more than putting enough weight into a car to make up a carload and getting it out to the railroad. Conditions today differ greatly in this respect. A customer may have a carload of steel on order which is rolled on several mills, and a week or ten days may elapse between the completion of the first and the last item. This means that most of the steel must be held in the shipping yard until the entire order is ready to be loaded, for no mill has enough track space to hold partly loaded cars more than one or two days at the most. Much storing and handling is therefore required before the bars can be loaded into railroad cars.

When a carload has accumulated, a car of the proper type and capacity is delivered to the loading track. However, loading is not what it was in the old days. Horizontal and vertical blocks must be placed between lifts, and lifts must be braced to prevent shifting when going gets rough. Some loads, depending upon the material, require an appreciable amount of lumber and labor for this purpose.

Occasionally a customer will specify that his steel must be protected from the weather. But he does not want it shipped in a box car because he wants to unload it with a crane. So he specifies that a good grade of water proof paper must be used. The amount of paper needed is sometimes surprisingly large. Much labor is also required in putting on the paper.

Marking steel by painting the ends of the bars to conform with the customers' color scheme has shown considerable increase in recent years and has added another to the many duties of the mill man. Every effort must be made to paint the end of the bars as specified, and as the men become more experienced and aware of the importance of this work they are doing a better job.

Certain bars are shipped pickled, others pickled and oiled, and others again pickled and limed. All of these processes require special equipment which constitutes a real expense if these facilities serve only one or two bar mills. Equipment of this type is able to take care of the output of several mills, as only a small part of the output of a bar mill requires such treatment. The same holds true for cold sawing, a few saws being sufficient to do all of the work for a number of mills.

The steel industry has made great progress in accident prevention during the past decade. This has not been accomplished by additional safety equipment only, but perhaps even more by increased efforts on the part of the personnel, from the manager down to the youngest worker. Particular efforts have been made by the supervising forces, and gratifying results have been obtained. The most effective method of making the average workman safety conscious is by meetings, in which small groups of men from the same location discuss safety, particularly the hazards that confront them in their daily work. In these meetings the individual worker is made to feel that he is an important

member of the family, and as he is given an opportunity to express himself he naturally becomes more interested in his own and his fellow worker's safety. The group meeting plan has reached further down the line than any other system formerly tried, and has given excellent results.

DISCUSSION

PRESENTED BY

H. J. BAUGH, *Assistant General Superintendent*, Carnegie-Illinois Steel Corporation, Youngstown, Ohio

W. H. BENNETT, *Superintendent*, Gautier Department, Bethlehem Steel Company, Johnstown, Pennsylvania

CLIFFORD ELMS, *Chief Engineer*, Pittsburgh Rolls Division, Blaw-Knox Company, Pittsburgh, Pennsylvania

F. E. LEAHY, *Fuel Engineer*, Youngstown Sheet and Tube Company, Campbell, Ohio

LOUIS MOSES, *Superintendent*, Rail Mill and Roll Department, Bethlehem Steel Company, Sparrows Point, Maryland

H. J. BAUGH: I would like to ask if you still use the stretchers on the hot bed for straightening hot bars.

W. H. BENNETT: We are still using those stretchers. We grip the two ends of the bar, holding one end in a fixed grip and the other end in a movable grip, that is, moved by a steam cylinder. The bar is then stretched from one to two feet, which takes the short kinks out of it. But stretching hot bars doesn't always answer the straightening problem of that particular bar, as the bar may be a non-symmetrical section, and will warp as it cools farther. But the stretchers do a very excellent job in pulling out small kinks that are very often the result of bad delivery from the mill, due to the non-symmetrical shape of the section.

H. J. BAUGH: Would you recommend them on high speed mills?

W. H. BENNETT: I don't think you could handle a large tonnage with them. Every bar must be handled individually, and there is a certain element of time required for the bar to be stretched and to be dropped out of the stretcher again. They are used only on the hand mills which produce a relatively low tonnage.

CLIFFORD ELMS: I don't know about all the improvements that the roll makers have made in their product. Of course, they are continually experimenting with new processes in making rolls, and making better rolls. Sometimes we get them. But I will have to say that after the rolls are made, it is really up to the roll designer and the mill to get the best out of the rolls. We can often put rolls into a mill that are, what we would call, excellent rolls for that job, and due to some misfortune in the mill, sometimes due to roll design, and faulty mill equipment such as was mentioned in this paper, especially poor guide equipment, the roll does not stand up to the job.

It often happens that the roll designer will leave the roll problem up to the roll maker, and we are not always familiar with the type of duty that this roll must perform, and naturally we often make mistakes.

Another thing mentioned was taking one section from one mill and putting it on another, and it didn't work. That may sound foolish to a lot of fellows here who are not familiar with the different rolling problems, but it is absolutely right. I have seen sections that have worked perfectly on one mill, transferred to another mill, on the same identical passes, put in the rolls, and the bar would be either short-legged or have some other defects, due to something in the mill which caused that particular trouble.

F. E. LEAHY: I am interested in Mr. Bennett's remarks on rolling to metallurgical requirements. I wonder if he would care to elaborate on the practice they use to meet the tolerances when the allowable depth of decarburization is specified.

W. H. BENNETT: Mr. Leahy, I am not prepared to go into any lengthy discussion of any of the problems that I have mentioned tonight. However, our decarburization limits are governed almost entirely by the furnace atmosphere, which must be closely controlled.

When a billet is charged into a furnace and heated, the surface of the billet is affected in two different manners:

1. It is oxidized very rapidly, resulting in the formation of an insulating coat of scale, and

2. Since the carbon in the steel has a greater affinity for oxygen than iron, the surface carbon combines with the excess oxygen in the atmosphere to form carbon monoxide and carbon dioxide and this escapes. Due to the lowering of the carbon content on the surface there is a continual migration of the carbon towards the surface of the piece. This action is progressive so long as the steel is kept under unfavorable conditions and continually increases the depth of the lower carbon case.

Conditions which control the rate of decarburization of a billet in the furnace are:

1. Grade of steel. In a low carbon steel the reaction is not severe because it lacks the carbon content to support migration. As the carbon content increases, the severity of the reaction increases. Also certain of the alloying elements have a detrimental effect on the steel from a standpoint of decarburization.

2. Composition of the atmosphere. The proper air-gas ratio is necessary as well as the proper composition of the other gaseous constituents in order to prevent decarburization. Moist hydrogen and water vapor are especially detrimental.

3. Temperature obtained. Decarburization can take place at any temperature above the lowest scale forming temperature (approximately 1300 degrees F.) and continues more rapidly as the temperature increases.

4. Time at temperature. Since decarburization is controlled by the rate of migration towards the surface, the time at temperature is an important function.

5. Amount of reduction from billet to finished bar. The larger the billet used for a given bar size or the smaller the bar rolled from a given billet size, the less the amount of decarburization encountered on the finished bar.

LOUIS MOSES: Should we go back some twenty-

five years it would be found that the roll materials then in universal use consisted of the carbon steels, sand irons and plain chill. The steel roll, often merely flask annealed, was strong enough but guttered and fire cracked. (The alloy steels of today still fire crack for that matter.) The sand irons conferred good finish in intermediate positions but their life was relatively short. Under its limitations of strength the chilled irons are hard to beat today in ability to confer a fine finish to a bar.

In recent years coincidental experience was had on two widely separated large shape mills, the objective in each unrelated case being to try out the formerly used irons. Both of these old mills initially employed the above materials and then used the modern alloyed varieties as they were developed. My own experience was not encouraging and if for nothing else proved to me the superiority of the modern grain type metal. On the other mill I understand that the sand iron proved to be a successful reapplication.

St. Clair DISCUSSION

(*Continued from page 63*)

be the best answer because of its high red hardness and toughness. This recommendation would include cuts with feeds up to 1/16 in. and a depth of 1/2 in. For 1/8 in. feed or more, the 18-4-1 H.S.S. would work best because of the great strength required in the tool.

STEVE KNAPP: But what about jobs where you have hard spots? What tool would you recommend there—as on locomotive tires, for instance? There are hard spots and then soft spots, and that is one of my problems.

L. J. ST. CLAIR: 18-4-1 is the only tool that will do such a job. You are not cutting the hard spots; you are breaking them off, and you don't do it fast. In such a case, toughness is the most important thing, so "toughness" is the chart section you refer to. I think that is a simple way of using your judgment.

Wolfe DISCUSSION

(*Continued from page 60*)

early work with high strength rivets and in our experiments to get away from that difficulty we discovered two things. The first was the time element. We now "keep on" a rivet with a bull machine between fifteen and twenty seconds. That is a lot of time and increases the cost of riveting. Second, we found that if the hole is slightly countersunk on both sides we get away from a sharp corner, which is apt to set up a cooling crack in the air-hardening rivet material. One has to be careful about the countersink. Keep it to a minimum of not over 3/32 of an inch, because if the countersink is much larger, a layover develops between the head and the shank of the rivet which results in a crack which is the finest invitation for a failure.

I would like to ask Mr. Wolfe a question which he may know about. I ran into it in Washington in dealing with the Navy Department the other day; it was new to me. That is the use of unmachined score sheaves of large diameters. I was very much interested when that was brought up by the Navy Department. Can you tell me something about that? Have you used unmachined scores in sheaves and is it generally the practice with your company? One could thus save a lot of money on sheaves if this were accepted generally. We have a number of large shipyard cranes going through our works now on which there are about 850 sheaves and I would like to eliminate the scoring of the grooves if we can get away with it.

G. F. WOLFE: I haven't gone into that Navy specification. It may exist on cranes we are now building under the Navy program. We have been using rolled steel sheaves on practically all of our cranes for the past ten years, so we seldom have the problem referred to.

A. E. GIBSON: This was on 150-ton cranes, shipyard cranes of the overhead traveling design, and they told me in the Navy Department that they had approved the use of unmachined score sheaves. I told them I had never heard of it before, but if it was satisfactory we would save a lot of money.

THOMAS E. HUGHES: There is one question I should like to ask in connection with Mr. Wolfe's excellent paper. I would like to know what his practice is regarding braking on the trolley motion. Does he use any emergency braking such as air operated rail clamps or other similar equipment in addition to the conventional electrically operated motor brakes?

G. F. WOLFE: No, not on the trolley. We use no emergency clamps on the trolley. We depend on the motor brakes.

Modern Design of ANNEALING COVERS

By Lee Wilson, President

LEE WILSON ENGINEERING CO.

Cleveland, Ohio

Presented before A. I. S. E.
ANNUAL CONVENTION, Cleveland, Ohio
September 23-24-25, 1941

▲ PEOPLE often ask what were the leading or most important factors in the success of the tube type annealing furnace. First, in my mind, was the spring meeting, in 1934, of the Association of Iron and Steel Engineers. At that meeting in Youngstown I made a lot of very good friends who encouraged me and offered many valuable suggestions. In the years that followed many of you worked out the tough operating problems which are always present with a new development.

The second most important factor as I see it, is the fact that other progressive companies decided to go in the radiant tube business, offering prestige to the idea and contributing many worthwhile developments to this type of heating.

The result of these two major factors is the development of the present annealing furnace. The coöperation of you folks as users and the competitive spirit of development, which was brought about by others entering the field, is illustrative to my mind of the American way of life that has proved so beneficial from every standpoint. Back in those days the ever present question among many steel men was, "Where can I buy a production annealing furnace which will do a high class annealing job?" Today the question is, "Which one of three furnaces will I buy?" Annealing furnaces are like automobiles—any of the three are good. It is merely a question of which type fits the need of the individual user the best.

TYPES

Speaking of types, there are three standard types of sheet annealing furnaces:

First, of course, is the portable bell radiant type which fits the need of a man requiring a high quality job on a productive basis. His job must not, of course, exceed 1800 degrees F. in temperature.

Next comes the in and out direct fired type which is sometimes used where only lean-to space is available, or where other physical plant conditions make the first cost of this equipment to the company more advantageous. The temperature range of this equipment is probably limited to 1500 degrees as it cannot be used without annealing boxes of some type. Then comes the portable bell electric furnace which is chiefly used for high quality annealing above 1800 degrees.

Figure 1—View showing rectangular bell type furnace, the bell being lowered over eight inner covers holding stacks of tinplate coils.

In addition, there has been some small amount of development work done on direct fired portable bell furnaces, but as yet this type has not been generally accepted. The lack of acceptance is probably due to the fact that the chief claim of this furnace is the elimination of radiant tubes. Of course, most people realize

Figure 2—This standard cylindrical bell type furnace, with vertical radiant tubes, is used for coiled strip annealing.

that radiant tubes were the thing that made high quality production furnaces, such as we now have, possible.

FUTURE HEAT TREATMENT OF FLAT ROLLED STEEL

The question of interest to all of us is, "Where do we go from here?" when it comes to progress in heat treatment of flat rolled steel. That is what I would like to discuss more in detail. I very well remember one of the favorite statements of Charles Kettering. He once told the writer he believed that a thorough understanding of the problem at had was at least eighty per cent of its solution. He never, at any time, tried to do any creative thinking on a development problem until he thoroughly understood what the problem was. At the present time I do not believe that anyone could put down in writing what the annealing problem is, so far as flat rolled annealing is concerned, and until the time comes when someone can thoroughly understand this problem, we are not going to get the ultimate in annealing furnace design.

There are certain definite trends at the current time which the steel industry and the furnace industry are following as far as development is concerned. These can be set down as follows:

1. Minor improvements in the types of furnaces previously mentioned.
2. The moving of the source of heat from the outside of the inner cover to the inside where it will be in direct contact with the work.
3. Change to strand or continuous annealing.

IMPROVEMENTS IN PRESENT DESIGNS

Let us take up these three trends and discuss them more in detail. First of all let us discuss improvements in the present designs. A great deal of work has been done to try and improve flexibility of heat distribution. In many cases circulating fans have been installed in the bases to speed up heating and improve distribution of temperature to the work. These, of course, have only been used in furnaces which are heating coils. Circulating fans do two things when properly applied—they give the combination of convection heating and radiant heating to the furnace which originally relied 100 per cent on radiant heat. It makes it possible to reduce slightly the temperature head necessary for transmitting the heat. This is beneficial from the quality standpoint, or, in case that higher production is desirable, it permits a shorter cycle with the same temperature head, thereby increasing the capacity of the furnace. A survey of a number of applications of this type shows an improvement in production from fifteen to twenty per cent, with a corresponding reduction in fuel costs.

It has been found that the use of circulating fans is of much greater benefit when cylindrical inner covers are used with one fan doing the circulating for each individual inner cover. When a multiple number of fans are used in a rectangular inner cover there is so much waste space between the cover and the charge that the circulation of gases is at a very low rate, and in most cases the fan does not give sufficient improvement to justify its use.

For a time there was a great deal of thought given to increasing the possible radiating area of the tubes by putting in additional tubes or making the tubes longer. It was thought that by doing this, greater capacities could be achieved. It was soon found, however, that no increase in capacity was achieved when using rectangular inner covers. This led to the conclusion that the real bottleneck of annealing, from the standpoint of capacity as well as heat distribution, was the inner cover. It was further found that a direct relationship existed between the absorptive area of the charge and the absorptive area of the inner cover. This is the explanation why such large tonnage can be obtained from tin plate furnaces that have individual cylindrical inner covers. In this type of furnace the area of the inner cover, in relation to the charge, is a great deal higher than in furnaces using only one large rectangular inner cover. It was also established that additional tube area beyond a certain point, even with cylindrical covers, was of no value, as the bottleneck of the heating problem was the nner cover and not the original heating source.

Many various shapes and types of tubes have been tried as a result of a constant endeavor to find the most effective design. There are three things which influence the type of tube used:

1. It is the necessity of getting controlled heat distribution both horizontally and vertically.
2. It is the desire to obtain the greatest possible tube life together with ease of changing tubes when repairs are necessary.
3. It is the perpetual desire of every engineer to improve the efficiency of fuel utilization.

Fundamentally, there has been very little change in the type of tubes which were used most advantageously in the early days. One manufacturer holds pretty well to the horizontal type, although in some cases, he has found it necessary to use a vertical tube to meet certain conditions. We have held fairly close to the vertical tube although, likewise, in certain cases we have found it advantageous to use the horizontal.

The question of whether to use rolled sheet alloy or cast alloy is still one from which many arguments can arise. Both of the foremost tube type manufacturers have used both types. From the first cost standpoint there can be very little difference in the two types of tubes. The cast tube is, of course, heavier, and has more poundage in it but can be bought at a considerably lower price per pound, while the fabricated type is considerably lighter, raw material in sheet form is considerably higher in price and the additional cost of forming and welding of this tube brings it up to an equal cost to the cast tube or even higher.

We feel that the fabricated tubes have certain inherent advantages.

1. We know that the whole wall section is uniform in thickness which we were never sure of in a casting.
2. We know that the tube material has been subjected to much closer inspection than is possible in the cast tubes.
3. We know that the tube wall is thinner thereby assuring a lower internal tube temperature than is possible with a cast tube.

4. In addition to this it is an advantage in some cases where the weight of the furnace is an important factor as the fabricated tube reduces the tube weight in the furnace about one-half or less.

Our competitors have many good arguments for the use of cast tubes. We know, because we have been up against them many times. However, from a customer's standpoint there probably is not a great deal to choose between the two; at least my observation, over a period of years, has led me to believe that a good job is done with either type.

Taking a furnace out of service to repair an individual tube is always a costly procedure and today, with our intense desire to get high production from every possible machine, it is a distinct disadvantage. The vertical tube of parabolic shape eliminates the necessity of shutting down the furnace to change the tube. Tubes of this type can be taken out of the furnace and a new one placed in the furnace while the furnace is in operation. This has been done on many occasions to demonstrate the possibility of maintaining production.

Many people have questioned the advisability of using such a large number of vertical tubes as it is possible to do the job with a much fewer and longer length tubes either in the form of U or W shaped tubes. There is, undoubtedly, some advantage to longer length tubes—fewer number of burners to maintain, and a slight saving in first cost. However, we believe the advantages of temperature control, which are inherent to a furnace where the heating units are broken up into very small parts, far outweigh the advantages of the longer tube. In addition, the advantage of being able to service a tube while the furnace is in operation is lost when longer tubes are used. It is always possible to shut off several of the short tubes without materially affecting the total charge. This is a material benefit when tube service is required during a heating cycle.

The greatest advancement in efficient fuel usage has come from the closer control of secondary air. I believe this holds true with either the low pressure type or the high pressure type of firing equipment. With either of these systems the problem to overcome is the excess air which flows through the tube at low turndown. This problem has been carefully worked out for each system and has been completely eliminated.

So much for the improvements on radiant tube bells. When one looks back at the original radiant tube installations we find very little fundamental change. We find only the natural refinements which come from use and a competitive desire to make a better furnace.

DIRECT FIRED COVERS

To give a report on the improvements on direct fired bell type covers is rather difficult as it covers a much longer period of time, dating back to at least 1900, and probably earlier. I do not believe there is a furnace company that is interested in sheet annealing, that at some time has not done some work on direct fired bell furnaces. I am not familiar, of course, with all of them but I can tell you of the furnaces that have been built by our company, and I know that other furnace companies have also investigated the possibilities of eliminating tubes.

In the work which we did on this type of furnace, there were certain fundamental problems which we found very difficult to overcome. The one big problem in all types of annealing is the control of heat distribution within the furnace itself. It has been every annealer's desire to have a furnace with which he could positively distribute the heat to the charge, as he knew from experience what would bring the best results. We found with direct fired furnaces, of which we were acquainted, that this was a rather difficult problem as there was no way of controlling inside of the furnace the effects of heating gases. If the gases followed the predetermined path, good results were obtained, but, if due to changes in atmospheric conditions, or furnace pressure conditions, the flame was longer on one day than on another, these results were all upset.

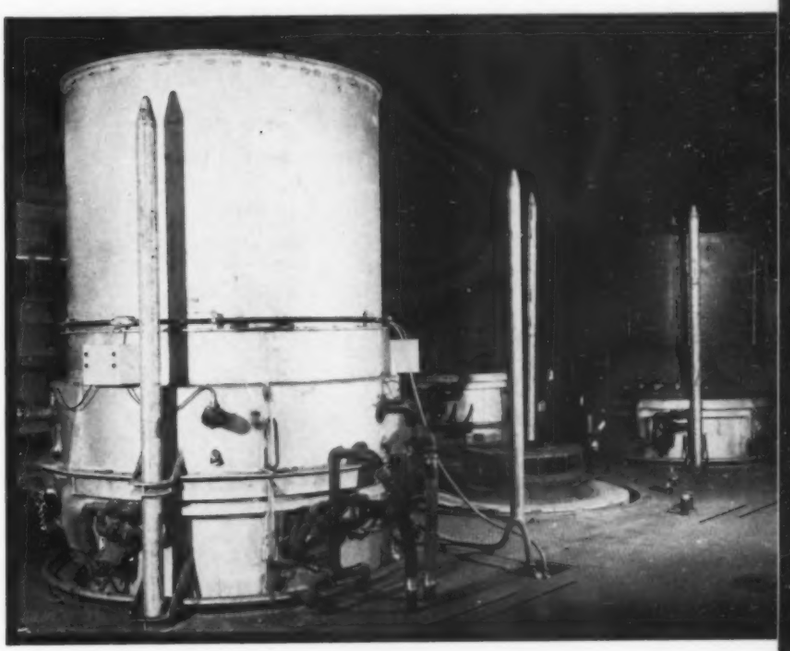


Figure 3—This view shows the base *(middle)*, the inner cover *(right)*, and the complete unit *(left)* of the firing retort type of furnace for coiled strip.

The tube type furnace made consistent results possible by confining the gases to certain restricted areas in the furnace. Each day these gases followed the same path regardless of atmospheric conditions or pressure fluctuations. This, of course, made it possible to get consistent results. There have been many claims that direct fired furnaces will operate more efficiently, from the fuel standpoint, than tube type furnaces. We have never found any conclusive evidence to prove these claims. From the theoretical standpoint it is easy to show why tube type furnaces are just as efficient as the best direct fired units can be. In either furnace the same amount of heat is available in the gases of combustion. The only possible difference could be in the method of taking the heat out of the gases and putting it into the charge. In the tube type furnace, the heat is released inside of the tube to form combustion gases which scrub

the tube at a very high velocity. The heat is transferred by convection to the tubes and from there to the inner cover by radiation. The temperature of the inner cover must be the same in either furnace to obtain the same heating time to a similar charge. Therefore, we again find that the inner cover is the bottleneck of the entire annealing situation.

In the direct fired furnaces the gases of combustion are released in the space between the inner cover and the outer furnace. These gases cannot impinge directly

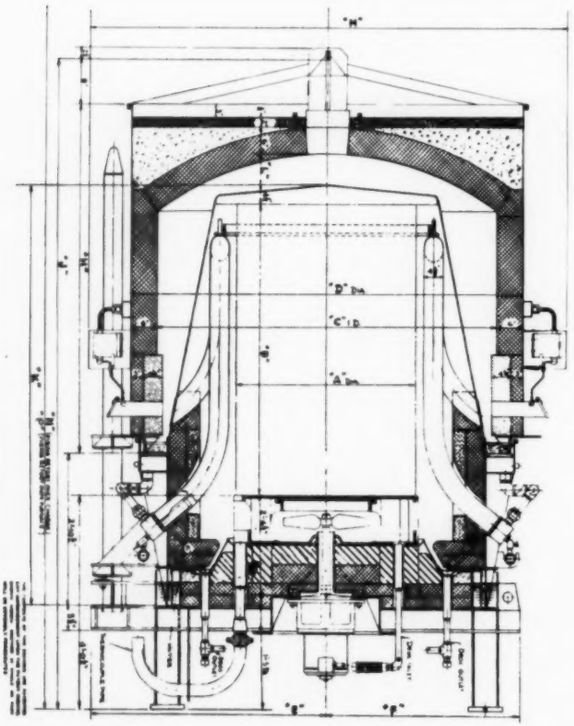


Figure 4—This sectional view shows the method of placing vertical radiant tubes in the inner cover of the firing retort type furnace.

on the inner cover as they would overheat that particular section. Some baffling effect must be obtained either by the burner or by actually placing a baffle between the burner and the inner cover. Here again, we are confronted with the inner cover being a bottleneck. All of the usable heat must be transmitted from the gases to the inner cover. The very low velocity of the gases in the direct fired cover, due to the very large space between the inner cover and the outer cover, make it necessary for these cases to have a much longer travel and a longer time in the furnace to extract the same amount of heat as is extracted in a relatively short travel of the gases in the tube type furnace.

Furthermore, it has been found necessary to use a heavier type of refractory in direct fired furnaces than is necessary in the tube type due to the direct contact of combustion gases with the furnace walls. Of course, the heavier refractories absorb sensible heat which is costly in batch operation.

One company for which we built five direct fired units and ten tube type units made careful investigation of fuel costs over a period of a year. At the end of the first six months the direct fired units showed a five per cent lower fuel cost than the tube type units. At the end of the next six months the tube type units showed a four per cent lower fuel cost than the direct fired units. At that rate, for the year, there was less than one per cent difference in fuel operating cost. This experience, together with investigations of other type furnaces, led us to believe that real progress in annealing will not come from direct firing bell type furnaces. We believe that the real source of trouble in annealing is the inner cover, and the only real solution to this bottleneck is to move the heating source inside of this cover.

As you probably all remember, our original radiant tube furnaces were used without inner covers, but it was soon found that it was possible to increase the overall productive capacity of the unit by using an inner cover for cooling the charge. When we first used inner covers we ran into a great many problems which we did not anticipate. We had set up certain definite capacities for furnaces of a given size. These capacities were based on not using inner covers and we found we got certain fuel efficiencies. However, when the inner cover was being used we found that the capacity of the furnace dropped some fifteen to twenty per cent, as far as heating time was concerned, with a similar increase in fuel per ton. Of course, these disadvantages do not outweigh the tremendous advantage of being able to use the heating cover while the charge was cooling, so the trend is to the use of inner covers, sacrificing the loss in fuel and heating capacity. The constant effort to increase capacities and get fuel efficiency similar to those made before inner covers were used has always been stymied by the inner cover bottleneck. All of the experimental work, all the new ideas, point to one thing —the elimination of the inner cover or the placing of the heating source inside the inner cover.

FIRING RETORT FURNACE

About four years ago we began development work on a new furnace which we termed the firing retort furnace. Fundamentally, all we did was to place the tubes inside of the inner cover and exhaust the gases between the inner cover and the insulating hood. After several years of experimenting, this furnace was successfully put in operation at the Superior Steel Corporation, Pittsburgh, Pennsylvania. It is interesting to report that from the first productive heat, this furnace gave us back the efficiencies in production and fuel that we had originally lost when we went to the use of inner covers.

Figure 3 shows a cross section through this new type of radiant tube furnace. The cylindrical furnace was tackled first because the problem of expansion and contraction in the cylindrical cover was much less severe than in a rectangular cover and we feel that we should creep before we walk.

The firing retort utilizes the same base design as is used in the standard radiant tube cover. In place of

the inner cover, a firing retort is used. This is a combination of inner cover and firing cover. The lower section is lined with insulating brick about one-third of the way up; the tubes enter in the same relation to the charge as in the older type unit. The upper two-thirds of the retort consists of a plain cylindrical alloy inner cover.

In addition there is an insulated hood which confines the heat and allows the waste products of combustion to be further utilized. The travel of the heating gases is from the burner at the lower end of the tube up through the U tube, exhausting between the firing retort and insulating hood. At this point they travel up and out of the flue at the top of the insulated hood. By the time the exhaust gases have left the tube they have been reduced in temperature to a point where they can do no harm to the inner cover and are high enough in temperature to supply the necessary heat to take care of the radiation losses from the insulating hood.

One of the most outstanding advantages with this type of furnace is from the quality standpoint. Due to the very large radiating area directly exposed to the work it is possible to obtain high capacities with extremely low tube temperature. In fact, in all of the furnaces we have in operation today of this type, the highest reported differential between the tube and the work is 75 degrees. This differential exists for a period of not over one hour. The average throughout the industry is closer to 50 degrees differential. This very low differential is very beneficial from the standpoint of eliminating spot heating or the possibility of overheating the outside wraps of the charge. In addition to the quality advantage, such a low tube temperature means much longer tube life and longer inner cover life.

At this point it might be worthwhile to point out that tubes in furnaces of this type can safely be guaranteed to last three times as long in time as the tubes in an orthodox radiant tube unit. The tubes in a firing retort unit are only used one-third as often as in a standard cover. The next step forward in portable bell type annealing is, undoubtedly, the application of the firing retort for all types of bell furnaces. The tremendous advantages found in the cylindrical retort type would justify the determined effort on the part of manufacturers and users to adapt this principal to rectangular covers.

STRAND ANNEALING

It has probably always been desirable, at least it has been so to me, to continuously anneal strip steel. Continuous annealing of any type of product appeals to the average engineer from the production standpoint. In fact there have been a great many attempts to do this type of annealing. The United States Steel Corporation, Ford Motor Company and numerous others have spent thousands of dollars in developing continuous processes. Most of these processes, however, have been on the annealing of auto body strip or sheet, which is probably the toughest annealing problem in the flat rolled industry. Unfortunately, none of these experiments with auto body strip have proved successful.

Perhaps the approach to the problem has been too ambitious, perhaps greater progress would have been made if an easier problem were tackled first. The knowledge gained in doing the easy problem can be applied in licking the tougher problem, at least this is the feeling in our minds. We are attacking the problem from the standpoint of tin plate because we feel that the annealing problems in tin plate are very much simpler and more easily accomplished than those of auto body sheet or similar products. Undoubtedly, there are many who do not agree. However, in our experience we have found this to be the case. In approaching continuous annealing, we have thought in terms of vertical furnaces rather than horizontal. Continuous furnaces, to give a reasonable capacity, would have to be extremely long, and would take up too much valuable floor space. At the present time a vertical annealing furnace which we term "tower type annealing furnace" is being constructed for the annealing of tin plate. This furnace is being heated with radiant tubes and, of course, has a protected atmosphere so as to produce a bright product.

Units of this type include two coil holders, pinch rolls, shears, welder, pinch rolls and mechanical loopers for taking up the slack during the welding process, the annealing tower, three cooling towers and on the discharge end of the furnace, another set of pinch rolls, mechanical looper, set of bridle rolls and the reel.

One user of tin plate is operating successful furnaces of this general type at the present time. These furnaces are electrically heated and are used for the annealing of high Rockwell tin plate. The results obtained in these furnaces are very encouraging. We believe that even the lower Rockwell grades can be successfully annealed. However, a more thorough report, based on experience with the radiant tube unit which is now in an experimental stage, can be given at a future date.

In this paper I have tried to make a report on the state of the annealing furnace situation. Unfortunately, it has not been possible to more than touch on the subject, but if I have succeeded in calling attention to this problem so that it will receive some future thought, I will have accomplished my purpose.

Items of Interest

K. E. Dinius has been appointed chief engineer of South works of Carnegie-Illinois Steel Corporation as announced recently.

Before becoming associated with Carnegie-Illinois, Mr. Dinius was with General Electric Company in Ft. Wayne, Indiana. He came to South works in 1924 as a repairman in the electrical department and served in this capacity until 1929, when he was made testing engineer. In 1935 he became superintendent of the electrical department and a year later was transferred to the engineering department as an electrical engineer, the position he held until his present appointment.

Mr. Dinius is a graduate of Purdue University and a member of the American Institute of Electrical Engineers and the Association of Iron and Steel Engineers.

A. G. Pratt, president, Babcock and Wilcox Company, and **C. M. Chapin, Jr.,** vice president, St. Joseph Lead Company, were among those recently re-elected to the board of trustees of Stevens Institute.

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"HEAVY STARTING LOADS PLAYED 'HOB' IN OUR DYE HOUSE . . .

- but not since we Cloth Dryer

THE FACTS: "Last May (1940)," continues Mr. Eisenhart, "we installed a cloth dryer in our dyehouse. The manufacturer had equipped the machine with 100 ampere, 250 volt fused switches and 100 ampere renewable fuses.

"Heavy starting loads, however, played 'hob' as the fuses on the machine kept blowing.

"Knowing about the long time-lag feature of BUSS fuses proved to be a lifesaver for us — for as soon as we replaced the other fuses with BUSS fuses we stopped having these starting shutdowns."

WHY LET USELESS SHUTDOWNS COST YOU MONEY — WHEN YOU CAN PREVENT THEM?

It is easy to see that useless shutdowns cause a real money loss. Stalled machines, idle workers and interrupted production don't pay dividends.

Doesn't it become a matter of executive importance, therefore, to select fuses that will do their part to reduce to a minimum all needless interruptions of electrical service?

BUSS

"equipped our with Buss Fuses"!

R. Eisenhart, *Electrician*
Belle Knitting Co., Sayre, Pa.

BUSS design prevents needless blows

The Super-Lag development in the fuse link gives BUSS fuses a time-lag long enough to hold most starting currents or harmless overloads. Hence, when two or more motors start at one time or machines jam momentarily or other such things occur BUSS fuses will generally hold —and the circuit will be kept in operation.

The BUSS fuse case also does its part to prevent needless blows. It guards against poor contact developing within the fuse itself. This eliminates poor contact heating that so often is the cause of ordinary fuses blowing needlessly.

Why not help to eliminate money losses and work stoppage periods in your plant by passing the word along that all purchase and stock records must be changed to call for BUSS Super-Lag fuses. If you would like complete information to give to other men in your plant, write for Bulletin RCS.

Bussmann Mfg. Co., University at Jefferson, St. Louis.
Division McGraw Electric Company

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ITEMS OF INTEREST

H. T. Florence has been named vice president of the Cleveland Crane and Engineering Company, Wickliffe, Ohio. This position is in addition to his present capacity of general manager. Mr. Florence has served with the company for 20 years in various shop departments, engineering and sales. He has been an associate member of the Association of Iron and Steel Engineers for many years.

H. A. Hudson, formerly manager of the motor sales division of the Wagner Electric Corporation, St. Louis, Missouri, has been promoted to the position of manager of sales of the electrical division. The electrical division is comprised of the home office and the 25 factory-owned branch offices located in principal cities throughout the country and includes the following Wagner products: motors, transformers, fans and industrial brakes, in both the domestic and export markets.

Mr. Hudson was graduated from the University of Kansas in 1924 with a degree in electrical engineering. He enrolled in Wagner's student engineering course the same year and entered the sales department in 1925. The following year Mr. Hudson was promoted to the position of manager of large motor sales, and in 1932 his management was extended to include the sale of both large and small motors.

W. S. Davis, Jr., assistant sales manager of Penola Inc., since 1934, has been appointed manager, succeeding **D. V. Stonaker,** who retired on November 1. Mr. Davis also has been elected a director and vice-president. His offices are in Pittsburgh, headquarters of Penola, which is an industrial lubricants marketing affiliate of Standard Oil of New Jersey.

All of Mr. Davis' experience since his graduation in 1924 from Lehigh University with a degree in mining engineering has been in the petroleum business. He began his career as a laboratory assistant in the development department of the Standard Oil Company of New Jersey at Elizabeth, New Jersey, and three years later became a lubrication salesman at Trenton, New Jersey.

In 1929, he joined the Standard Oil Company of Pennsylvania and advanced in various sales capacities to management of lubrication sales, which position he held for four years prior to his joining Penola as assistant sales manager.

Mr. Stonaker, whom Mr. Davis succeeds, had been sales manager of Penola since 1935. He had been in the petroleum business for 25 years, his time being devoted to lubrication sales throughout his service with Standard of New Jersey, Standard of Pennsylvania, and Penola.

A. Milne Ramsey, formerly district manager at the Pittsburgh office of the Carbone Corporation, has been transferred to Boonton, New Jersey, where he will be factory manager of the Carbone Corporation.

Paul G. Pendorf, sales engineer, Eastern territory, has been transferred to the Pittsburgh office of the Carbone Corporation, succeeding Mr. Ramsey.

Robert McKeown and **Charles V. Allen** were named district representatives, succeeding the late E. A. Berger, sales engineer, at the Keystone Carbon Company's new Eastern sales office at 249 High Street, Newark, New Jersey. This company, whose main office is located in St. Marys, Pennsylvania, manufactures commutator and slip ring brushes, porous bronze bearings, negative temperature coefficient resistors, and electrical contacts.

The Keystone Carbon Company also announces the appointment of A. A. Barbera and Company, 417 South Hill Street, Los Angeles, California, as representative for Keystone products in the Southern California territory.

Russell J. Greenly, chief of training and education will assume additional duties as acting chief of the personnel division as announced by the Carnegie-Illinois Steel Corporation. In the personnel post, Mr. Greenly will occupy the former position of **J. Edward Johnson,** who was recently promoted to the superintendency of industrial relations at Clairton works.

W. S. DAVIS, JR.

H. T. FLORENCE

H. A. HUDSON

The corporation also announced the transfer of **Charles D. Feight,** formerly superintendent of industrial relations at Clairton, to the staff of the vice president in charge of industrial relations at Pittsburgh. **Edward P. Woodward,** formerly personnel assistant at Pittsburgh, has been transferred to duties of increased responsibility on the industrial relations staff of the Youngstown, Ohio, District works.

Mr. Greenly was born at Philadelphia, Pennsylvania, March 24, 1895. He received a bachelor of science degree at the Pennsylvania State College in 1930 and a master of science degree at the Akron University in 1932. Since then he has been working toward a Ph.D. degree at Western Reserve University. Mr. Greenly began his industrial career with the DuPont Company at Wilmington, Delaware, in 1914, and in 1921 became associated with Sun Shipbuilding Company at Glovester, New Jersey. Entering the field of education, he was director of voice education at Abington High School, Montgomery County, Pennsylvania, 1922 to 1927; and in 1927 became a professor at the Akron University. From 1936 to April, this year, Mr. Greenly was a professor at Purdue University.

Mr. Johnson, formerly chief estimator at Clairton works, since 1936 has been associated in various capacities in the industrial relations department of the corporation at Pittsburgh. Mr. Johnson has held successively the position of Pittsburgh district director of training, chief of the training division and chief of the personnel division. He returns to Clairton with a record of wide experience in the broad aspects of industrial relations.

Mr. Feight, a 1929 graduate in metallurgy from Pennsylvania State College, was employed in the coking department of Clairton works during vacation periods while attending college and upon his graduation began continuous employment as assistant general heater foreman of the ovens department. He has been superintendent of industrial relations at Clairton works since July 17, 1939.

Mr. Woodward has been associated with Carnegie-Illinois since 1936, when he began employment as a practice apprentice at the South works, Chicago. He entered the industrial relations field in 1938 as supervisor of practice apprentices at South works and later the same year came to Pittsburgh as personnel assistant.

OBITUARY

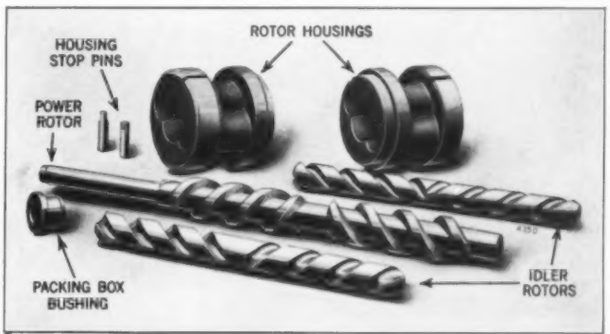
Julian Roe, for many years western sales manager of the Crocker-Wheeler Electric Manufacturing Company, died at his home in Chicago on November 24. One of the early pioneers in the motor and generator field, he was a definite factor in the development of the use of electric power in the steel, automobile and printing industries.

In 1894, one year after joining Crocker-Wheeler, Mr. Roe supervised the installation (at the Pencoyd Iron Works, later to become part of the American Bridge Company) of the first electric control system for transfer roll tables ever to be used in a steel mill. This was the first major electrification in the steel industry. In 1899 he was appointed Chicago district manager for

JULIAN ROE

Crocker-Wheeler and in 1927 western sales manager with offices in Chicago.

For many years, Mr. Roe was actively interested in the Electric Power Club, and in the National Electrical Manufacturers Association during its early days. He had been a member of the Association of Iron and Steel Engineers since 1912.



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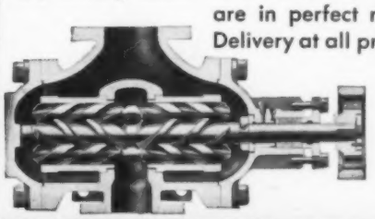
Internal parts of the *De Laval-IMO Oil Pump* are easily accessible, without removal from base plate or disturbing driving motor or turbine. The three moving parts are in perfect rotational balance. Delivery at all pressures and capacities is smooth and continuous, as from a piston moving steadily forward.



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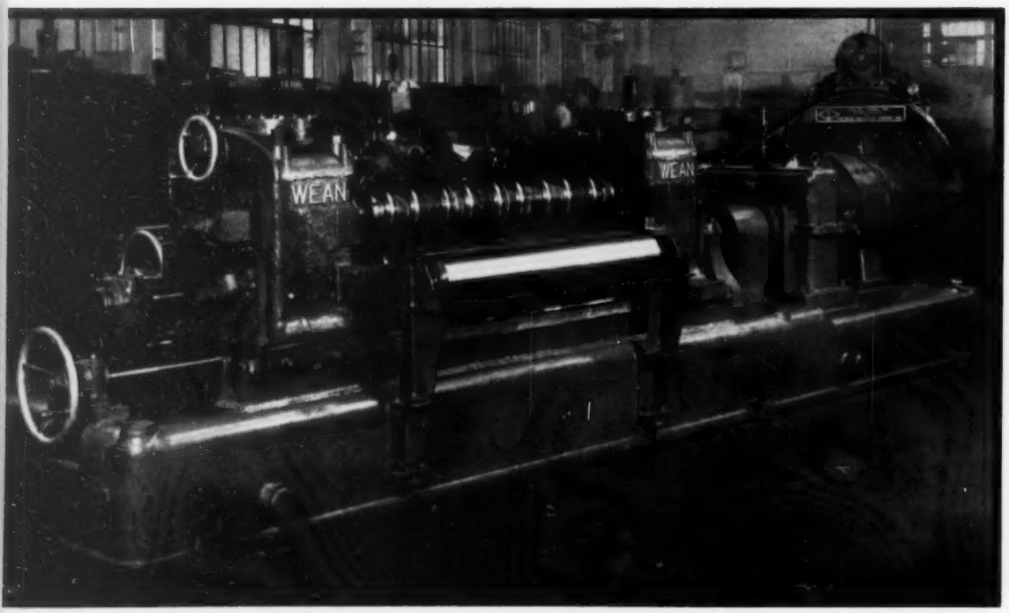
IMO PUMP DIVISION
of the De Laval Steam Turbine Co., Trenton, N. J.

SLITTING UNIT FOR WIDE GAUGE RANGE

▲ Production requirements in the plant often make it desirable to slit both light and heavy gauge strip on the same line. This practice presents a problem due to the fact that light gauges are best slit by knives of relatively small diameter, while larger arbors and knives are best usited for heavy gauges. This problem has been solved by the use of a combination slitting unit developed by the Wean Engineering Company, Warren, Ohio.

The combination unit has a main base on which the drive, with universal spindle connection to the arbors, is permanently mounted. The base is designed to receive either of two slitting assemblies, each consisting of portable base, housings, arbors and knives. One typical installation has an assembly of 10 in. diameter knives for slitting light gauge strip, and another assembly with larger arbors and 15 in. knives for heavier material. While one slitting assembly is in use, the knives on the other assembly can be set up for the next order.



Interchangeable slitting assemblies give great flexibility of operation over a wide range of gauges.

BOOKLET DESCRIBES FLOODLIGHT PRACTICE

▲ For nighttime production and protection in outdoor areas near manufacturing buildings, and for construction projects, recommended floodlighting practice is described in a new 22-page bulletin announced by Westinghouse Electric and Manufacturing Company.

Divided into six parts, the scope of the bulletin is as follows:

1. Typical applications of protective floodlighting.
2. Application of principles to the points requiring protection.
3. Application of equipment to points requiring protection.
4. Floodlighting for production.
5. Typical industrial plant applications.
6. Lighting units for protective and productive lighting.

Positions of lighting fixtures relative to ground and buildings are shown by drawings for the following applications: shipways, railway yards, freight terminals, storage and handling of materials, and building construction. Application data gives floodlight types, locations, spacing, aiming, and mounting type.

A copy of booklet B-2280 may be secured from Westinghouse Electric and Manufacturing Company, Cleveland, Ohio.

COMPANY CELEBRATES 50th ANNIVERSARY

▲ Celebrating its 50th anniversary, the Bonnot Company, Canton, Ohio, has published a complete history and review of the company in the November issue of its house organ, *Bonnot Newsette*. Founded in 1891, the company has had only three presidents during its life, the succession including M. D. Harter, L. C. Bonnot, and B. T. Bonnot, the last still remaining in office.

The anniversary issue is well illustrated with photographs of plant personnel and many old pictures taken around the turn of the century.

NEW TYPE GANTRY OFFERS ADVANTAGES IN LONG WELDING

▲ The Cleveland Crane and Engineering Company, Wickliffe, Ohio, has designed, built and recently installed in their structural department, a new automatic welding gantry for making long welds of 1 ft. 0 in. to 120 ft. 0 in. continuously and automatically. This equipment replaces the world's first welding gantry, which also was conceived and constructed by Cleveland Crane.

The new gantry has many novel features which make possible better welds, easier operation and improved working conditions for the operators.

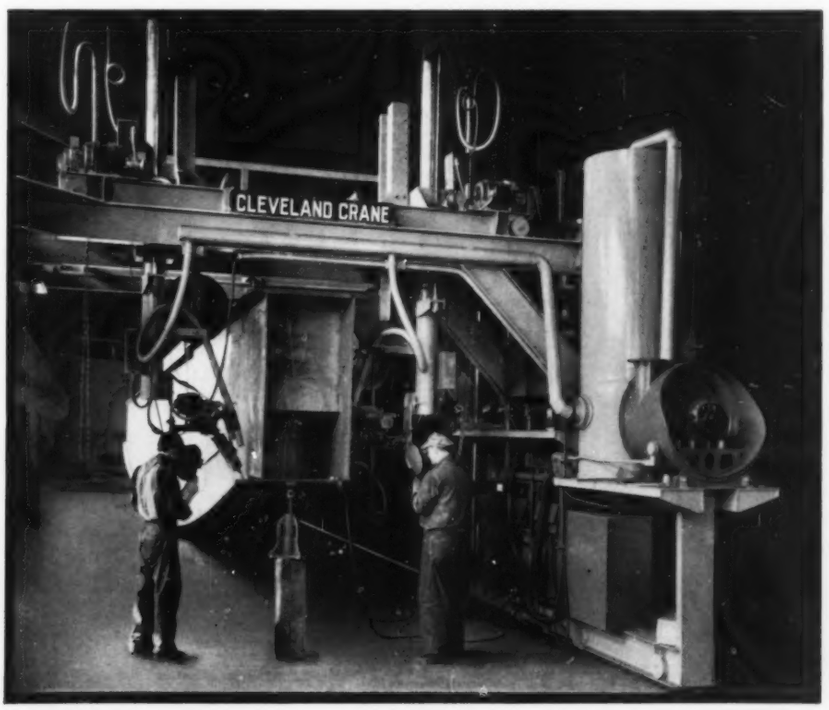
The machine can be traveled at any speed from 30 to 148 ft. per hr. to suit various size welds and materials. As the gantry travels, the welding rod is fed precisely and automatically to both sides of the work. In the welding heads a tape is wrapped around the rod to shield the arcs. By welding both sides of the work at the same time, the welding heat is distributed evenly, thereby neutralizing stresses and minimizing distortions that otherwise would take place, and thus produce straight accurate girders.

The welding heads are raised or lowered by individual push-button-controlled motorized drives that are mounted on separate hand-propelled trolleys which may be adjusted to suit the width of the work.

Located on a platform in the leg of the gantry are a motor-generator set for actuating the welding arcs; two welding transformers and control, with switches and meters. On this leg also is mounted an air-filtering unit which, by means of suction nozzles placed at the welding heads, removes the welding smoke and makes for more healthful working conditions.

Provision has been made for easily connecting-in hand welding equipment to make use of the welding transformers during periods when there is no work requiring automatic welding, or for places where hand welding is desirable.

The gantry is of the rigid all-welded steel construction and is provided with roller bearings throughout. It travels on two rails, one located on the wall and the other set in the floor. The travel motor drives wheels on both rails and thus assures even straight-line travel and eliminates possibility of crane skewing action.



This automatic welding gantry will make long welds, up to 120 ft. in length, continuously and automatically.

The photograph shows a girder for a 150 ton capacity crane being welded. This girder weighs 90,200 lb. and has a span of 105 ft. 0 in. Plates used for this girder range in thickness from 7/16 in. to 1¼ in.

TANK EQUIPMENT PLANT FOR PITTSBURGH

▲ The Defense Plant Corporation in Washington announced recently that it had authorized a $1,740,200 contract for a tank equipment factory at Pittsburgh to be operated by the Blaw-Knox Company.

An officer of the Blaw-Knox Company at Pittsburgh stated that while it had not received official authorization to proceed, it did have under discussion with the Defense Plant Corporation a plan whereby the Blaw-Knox Company would construct for the Defense Plant Corporation certain facilities at its Union Steel Castings Division which would provide for an extension to the foundry and the addition of certain equipment which would considerably increase the present output of armor castings.

The Union Steel Castings Division of Blaw-Knox Company has been one of the pioneers in the development and successful manufacture of armor castings which are being used by the Army for armoring tanks and by the Navy for various purposes.

CASTABLE REFRACTORY FOR FURNACE LINING

▲ A new light weight insulating castable refractory, recommended for service with temperatures as high as 2200 degrees F., has been announced by the Plibrico Jointless Firebrick Company, Chicago, Illinois. This material is applicable where refractoriness is required with high insulating efficiency, and is especially suitable for lining furnaces used for heat treating, annealing, stress-relieving, and carburizing, and for lining ducts, breechings, etc. Another valuable application is for backing certain types of water walls in steam boilers, when tube spacing and operating temperature permit. Called Plicast L-W-1, the material weighs 57 lb. per cu. ft., and sets in 12-24 hr. with a compressive strength of 1485 lb. per sq. in. Thermal conductivity, in Btu. per sq.

ft. per in. of thickness per hr. per degree F., is 1.80, 2.15, and 2.35 at mean temperatures of 400, 800, and 1200 degrees F. respectively. Heat storage capacity is said to be 60 per cent lower than that of fire brick.

MERCURY LAMPS MADE IN LARGER SIZES

▲ Hailed by lighting experts as a distinct contribution to greater speed in defense industries and to other manufacturing plants, the largest and most powerful mercury lamp in the world, was announced at Nela Park laboratories by General Electric Company's Lamp Department.

Designated as the 3000 watt G-E Mazda "AH-9" Mercury Lamp and rated at 120,000 lumens, this long tubular light source is eight times more powerful than the present largest lamp of its kind. Yet its 55 in. length is only four times that of its nearest rival, a 400 watt mercury lamp, rated at 16,000 lumens, chief source of illumination in many factories today. It measures a speck more than one inch in diameter.

This new tool on the industrial lighting front and suitable fixtures designed for its most effective use will probably be made available soon after January 1.

Nela Park engineers believe the "AH-9" mercury lamp will be a boon for the lighting of steel mills, foundries, erecting shops and for other large areas where lofty mounting heights of luminaires are required. It is regarded as a "natural" wherever swift and accurate human seeing is a vital factor in speeding up production.

Trial installations have proved that these streamlined "AH-9" mercury tubes—in good reflectors and on conventional spacing centers—can provide more than 50 footcandles of light evenly over the working plane. Latest available statistics show the average factory lighting level to be less than 10 footcandles.

The new mercury lamp illustrated here, although rated at 3000 watts, 120,000 lumens, is only 55 in. long and 1 in. in diameter.

Besides enabling industry to hasten production of defense materials, to speed up human seeing processes in industry, and to reduce the number of preventable accidents and spoilage attributed to improper lighting, the new 3000 watt G-E Mazda "AH-9" Mercury Lamp has several other outstanding advantages. Obviously, the reflector and transformer equipment required for best operation of a single "AH-9" is considerably smaller in bulk and less in cost than the aggregate equipments needed to produce a like amount of light from a system of eight or nine 400 watt mercury tubes in separate fixtures. Cost of servicing a single large unit, the engineers point out, will be considerably less than the expense of maintaining a group of smaller fixtures burning less powerful mercury lamps.

EXPANDING CAPACITY FOR SYNTHETIC MAGNESITE

▲ Construction work for the new plant of the Northwest Magnesite Company of Pittsburgh, Pennsylvania, is actively under way at Cape May Point, New Jersey. The Northwest Magnesite Company, jointly owned by the Harbison-Walker Refractories Company and General Refractories Company, has acquired the rights in the United States to the Chesny Process of producing synthetic magnesite for refractory purposes. The process has been applied in England on a large scale and has rendered that country independent of imported magnesite of natural origin formerly obtained from Austria and Manchuria.

To operate the Chesny process of producing synthetic magnesite, the Northwest Magnesite Company has acquired a large tract at Cape May Point, together with extensive deposits of dolomite rock in eastern Pennsylvania, located conveniently for shipment either by rail or by rail and water.

The capacity of the first unit will be approximately 40,000 net tons per annum. The layout however is such that additional units may be added as necessity might require.

The process was developed in England by Dr. H. H. Chesny, a resident of Los Angeles, California, working in coöperation with British producers of refractories. Several plants using the

process have been built in England, and now supply not only the requirements of refractory magnesite for the British steel industry but also the magnesia necessary for the production of magnesium metal. Magnesium metal has been produced in England from dolomite and sea water, starting with the Chesny process, since 1939.

This process, protected by a large number of United States and foreign patents, consists essentially in replacing the lime content of calcined dolomite rock by magnesia through reaction with sea water. Its commercial success is the result mainly of specialized knowledge of the involved crystallography of magnesium hydrate. This compound in its usual form is a gelatinous substance exceedingly difficult to filter. Only by the application of a highly specialized technique can it be produced in a crystalline, readily filterable state and easily separable from the sea water and from the various salts dissolved in it. A further factor in the success of the process has been the design and development of the highly specialized equipment required to meet the conditions of its various steps.

The erection of the new plant is financed entirely by the Northwest Magnesite Company. The Office of Production Management has granted priorities to permit the completion of the plant within six months.

During the late fall of 1939, Northwest Magnesite Company materially increased the capacity of its present plant at Chewelah, in the state of Washington. Still further facilities including a system of concentration by flotation have been under way for several months, and these additions by early December of the present year, will have nearly doubled the capacity prior to 1939. There is every reason for believing that any possible demands for magnesite in the basic steel industry can now be adequately taken care of as they may occur.

ANNOUNCES NEW LINE OF TRIPLEX PUMPS

▲ A new line of high pressure vertical triplex constant stroke pumps has been developed by the Aldrich Pump Company of Allentown, Pennsylvania. The pumps are of various sizes from 10 to 150 hp. for pressures up to 9800 lb. per sq. in. and capacities up to 220 gal. per min.

Improved design of this new pump makes it particularly applicable to gear-head motor or speed reducer drive. Provision has also been made in the larger sizes for the use of built-in gearing, or belt drive direct to crankshaft.

These pumps can be fitted with Aldrich patented synchronized suction valve control, as shown, for services such as central hydraulic accumulator systems where several presses are in constant operation. For special process work at the high pressures encountered in oil refining and the chemical industry the outboard plungers are sealed dust and weather tight with a removable cover. Many new features and refinements over and above usual pump design contribute to the high mechanical efficiency of this new line of pumps.

MAGNETIC DEVICE FOR VARIABLE SPEED DRIVE

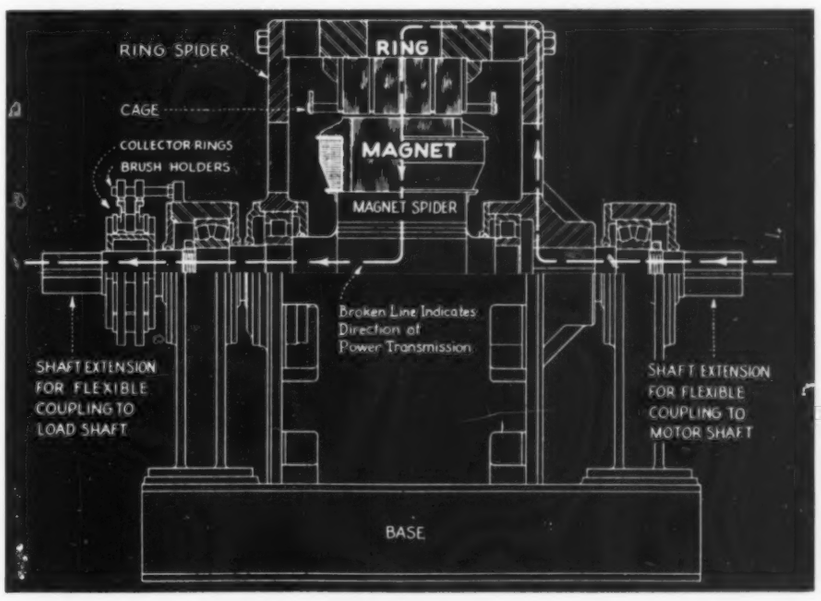
▲ A comparatively new development by Electric Machinery Manufacturing Company, Minneapolis, Minnesota, is a magnetic variable-speed drive which provides, in conjunction with a constant speed a-c. motor, a means of obtaining adjustable, wide-range speed changes for such applications as draft fans and centrifugal pumps and compressors.

The two torque elements of the new drive (see illustration) consist of (1) an outer "flux-linkage" ring of steel, which may have cage bars like the familiar squirrel-cage motor, and (2) an inner "flux-producing" magnet, separated from the ring by an air gap, and free to rotate. The ring is driven by a single-speed induction or synchronous type a-c. motor. The magnet shaft is connected to the load.

Operation of the magnetic drive unit is simple. As the ring is rotated by the driving motor the difference in speed between it and the magnet member results in a cutting, by the ring, of the flux produced by the magnet. Just as in a squirrel-cage motor, this sets up poles in the ring member. These poles drag around the poles of the magnet member. By adjusting a small exciting current to the magnet, its speed with relation to the speed of the ring, and hence with relation to the speed of the fan or other load to which it is connected mechanically, can be varied easily and with great preciseness.

These units have been well received, and indications point to a widening field of application in the industry.

This magnetic variable speed drive gives convenient, precise adjustment of load speed with constant speed drive.



NEW RAPID QUENCH OIL FOR SHELLS

▲ On the basis that a rapid quench is highly essential in the heat treatment of high explosive shells, E. F. Houghton and Company, Philadelphia, Pennsylvania, manufacturers of oils and heat treating materials, announces a new and proven quenching oil,

branded Houghto-Quench "G." This oil was designed specifically to meet the proper range of physical properties, including fire, flash and viscosity, as well as stability, freedom from sludging and rapid quenching speed.

Included in its make-up is a chemical agent which acts as a stabilizer and reduces oxidation or fractional distillation. A synthetic wetting agent is also embodied in Houghto-Quench "G" to provide rapid wetting-out properties, spreading a continuous film of oil speedily over the hot surface of the metal and preventing the formation of gas pockets.

REPORTS ADVANCES IN ELECTRO TINNING

▲ Sharon Steel Corporation has developed a new process for electroplating tin on steel sheets, strip and wire, which will effect a saving of approximately 40 to 50 per cent in pig tin per base box of tin plate. Pig tin is important in the current emergency.

A new United States patent, supplementing two granted previously, has been obtained by John S. Nachtman, director of research and development of the Sharon company.

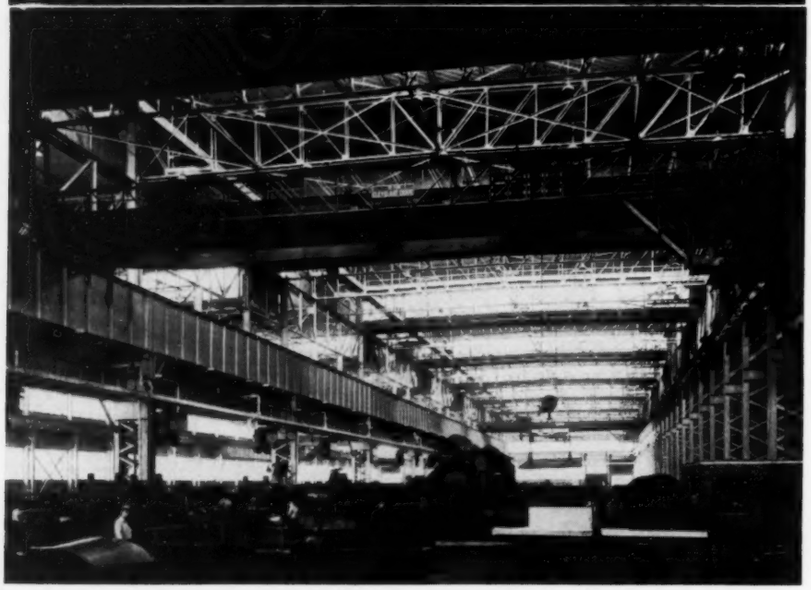
The new process consists of electroplating a "flash" coating of a metal other than tin on ferrous stock, then electroplating tin on the "flash" coating, and finally, brightening the tin coating by melting it. It is claimed for the process that the electroplated coating is non-porous, and is considerably more rust-resistant than the present hot dipped tinplate. Tinplate produced under the Nachtman processes has proved highly satisfactory for both wet and dry packs.

In addition, processes have been developed for both chemically and mechanically brightening electroplated tin. An acid tin electrolyte for use in electroplating tin on ferrous stock has also been developed. It is claimed for this electrolyte that a high current density can be employed, that it is self-maintaining, and that there is no formation of sludge.

Advanced methods for the production of alloy, stainless, and rustproofing coatings have been developed in the research laboratories of the Sharon Steel Corporation.

15TH ANNIVERSARY

CLEVELAND *All-Welded* CRANES



10 ton - 100'-0" span Cleveland all-welded crane with sheet lifter in a modern steel mill

THE BIG MILLS CHOOSE

CLEVELAND *all-welded* CRANES

Because so much depends on the crane service in the big mills, more and more Cleveland all-welded cranes are being purchased by them.

Cleveland all-weldeds are cheap insurance that *uninterrupted* crane service will be had whenever needed.

You, too, might prevent costly delays by installing Cleveland all-welded cranes.

THE CLEVELAND CRANE & ENGINEERING CO.
Wickliffe, Ohio

CLEVELAND CRANES

ALL-WELDED OVERHEAD TRAVELING CRANES

Other products: CLEVELAND TRAMRAIL and STEELWELD MACHINERY

CIVIL SERVICE SEEKS EDUCATIONAL WORKERS

▲ There is constant need for more skilled industrial workers to keep the wheels of industry turning for national defense. A partial answer to the grave problem of a diminishing labor supply is the apprenticeship program. In connection with this program, the Apprenticeship Section of the Division of Labor Standards, Department of Labor, is planning to appoint about 200 field representatives who will be stationed throughout the country. To fill these positions, which pay from $2600 to $4600 a year, the Federal Civil Service Commission has announced an examination in which applicants will be rated on the extent and quality of their experience *only*.

These field representatives develop national, state-wide, and local apprenticeship standards for a variety of crafts. Working in coöperation with union, industrial, and governmental officials, they promote programs for training men and women for industrial work and for establishing adequate labor standards to protect apprentices. In general, field representatives have the job of coördinating all phases of apprenticeship.

Applicants are particularly sought who are qualified in machine shop trades (machine tool construction,

operation, or maintenance) and aircraft and shipbuilding trades (construction or maintenance). Applicants may also qualify in building trades or any other apprenticeable trade. Two types of experience are required. Applicants must first have had appropriate "general experience" in industrial, trade union, trade association, or governmental work in the promotion of improved labor and employment standards in industry or in the administration of labor laws. In addition, they must have had "specialized experience," within the last 10 years, in the development or administration of apprenticeship. This may have been acquired in such capacities as shop foreman in charge of apprentices, teacher of organized apprenticeship classes, or trade union officer promoting the administration of an apprenticeship system. Provision is made for the utilization of a completed apprenticeship or journeyman experience in filling the general experience requirement.

Applicants must not have passed their 60th birthday for regular probational appointment. However, persons who are above this age limit or who do not meet the normal physical requirements, may have their applications accepted and be considered for temporary appointment in connection with the national defense program. Applications must be filed not later than January 12, 1942 with the U. S. Civil Service Commission, Washington, D. C. The examination announcement and application forms may be obtained at any first- or second-class post office or from the Commission's office in Washington, D. C.

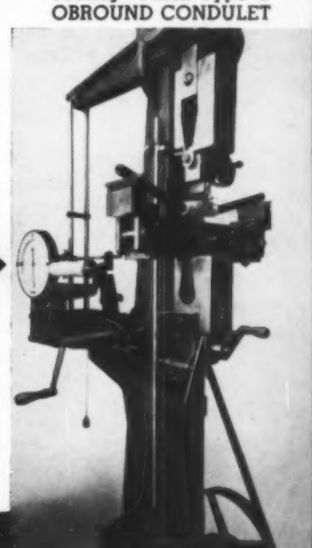
NEW CONDENSATE RETURN SYSTEM

▲ The essential engineering features of the Cochrane-Becker high-pressure condensate return system, as announced by Cochrane Corporation, Philadelphia, are that its educator principle of operation insures thorough condensate and air removal from process apparatus making increased production possible by maintenance of uniformly high temperatures. Then, after expulsion of the air from the closed circuit, the condensate is returned to the boiler at temperatures close to that of process pressure without flash loss and with remarkable fuel savings.

The specially-designed centrifugal pump draws water from the thermo-fin priming loop and discharges it as a high velocity jet through the jet pump nozzle. This jet, striking the returned hot condensate, induces condensate flow through the mixing tube into the thermo-fin priming loop. The additional volume of the returned condensate introduced into the constantly filled loop results in the discharge of an equal volume through the air separator to the boiler.

The closed circuit from the boiler, through the process equipment, and back to the boiler results in quicker and more uniform heating hence increased production and improved quality. At the same time flash loss is eliminated providing 1 per cent fuel saving for each 11-degree temperature gain. Write Cochrane Corporation, Philadelphia, Pennsylvania, for further technical information.

CONDULETS
MANUFACTURED ONLY BY
CROUSE-HINDS
Three of the outstanding reasons why **Condulets** do a better job are—
1 **FERALOY METAL**—Strong and Lasting
2 **TAPER TAPPING**—A Secure Joint
3 **FINISH**—Three Separate Protective Coats

1 FERALOY METAL
The result of an extensive research program, this alloy is perfectly adapted to Condulet requirements
Strong
Tough
Sharp Threads
Holds Shape
Resists Corrosion
Uniform Quality
Testing ¾-inch Type C OBROUND CONDULET
LOAD 1036 lbs.

Pipe broke at threads—CONDULET unharmed
A Nationwide Distribution Through Electrical Wholesalers
CONDULETS The Standard of Quality in the field of electrical conduit fittings.
CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.
Sales Offices: Birmingham Boston Chicago Cincinnati Cleveland Dallas Detroit Houston Kansas City Los Angeles Milwaukee Minneapolis New York Philadelphia Pittsburgh San Francisco Seattle St Louis Washington
Resident Salesmen: Albany Atlanta Baltimore Buffalo Charlotte Denver Louisville New Orleans
CROUSE-HINDS COMPANY OF CANADA, LTD. Main Office and Plant: TORONTO, ONT.

ANNOUNCES STANDARD CONTROL CENTER

▲ A standardized control center for motors has been devised that is not only adaptable to any combination of motors but also can be quickly changed to suit any new sizes of motor required by production alterations, according to Westinghouse Electric and Manufacturing Company engineers. The standard line starter and the associated line protective device for any of NEMA sizes 1 to 4 can be slipped into the control unit. A unit is made up of standard sections 20 in. wide by 90 high and 20 deep. The individual control elements are mounted on panels 20 in. wide and some multiple of 14 in. high, so that from two to five control elements can be stacked in a single section. Wiring is brought in from either top or bottom of the section, as convenient, and runs vertically in duct behind the control units. The controls are completely front connected, which, with preformed wiring, makes removal both safe and easy. Because the control section is 20 in. deep there is sufficient space in it to mount control elements in each side, *i.e.*, back to back, if desired.

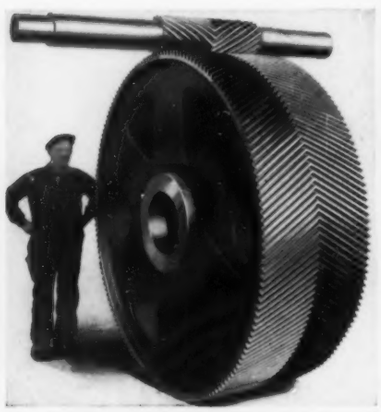
FARREL-SYKES GEARS
for Rugged, Smooth Running
ROLLING MILL DRIVES

Farrel-Sykes Gears for rolling mill drives meet today's defense production demands for ruggedness, for ability to withstand the shocks, stresses and wear incident to high speeds and heavy loads, and for efficient, trouble-free performance.

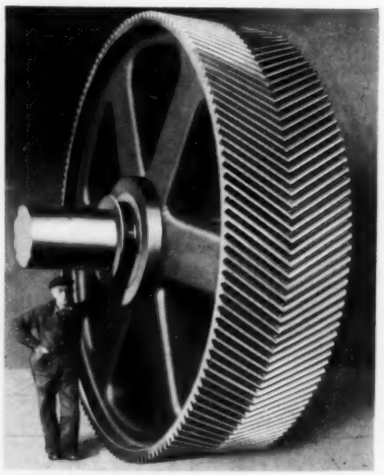
With the greater bearing surface provided by their continuous herringbone teeth, Farrel-Sykes Gears are stronger and better able to carry heavier loads at high speed. In consequence, they offer the advantages of reduced weight and size for a given load requirement, together with exceptionally quiet, smooth-running operation.

Due to the interlacing and creeping engagement of their teeth and inclined line of pressure, Farrel-Sykes Gears are better able to withstand wear. And their involute profile and correct tooth action are maintained as long as the gears last. Furthermore, their opposed helices balance and absorb axial thrust within the gear member, eliminating harmful thrust loads and resultant stresses on other parts of the machinery.

These are but some of the many features that account for the long-lived, economical performance of Farrel-Sykes Gears for rolling mill drives. Farrel engineers are always available for consultation on gear problems.



High ratio gears for a rolling mill drive. In the limited space available only continuous tooth herringbone gears were able to meet the requirements.



Continuous tooth herringbone gear for rolling mill drive, 5,000 HP, weight 61,700 lbs., 145" diameter, 145 teeth, 1 DP, 40" face.

FARREL SYKES GEARS
FARREL-BIRMINGHAM COMPANY, Inc.
ANSONIA, CONN. - - - - - BUFFALO, N. Y.
The Gear with a Backbone

NEW PLANT TO MAKE SUPERCHARGERS

▲ Construction of a $25,000,000 factory at Fort Wayne, Indiana, for the manufacture of turbo-superchargers for airplanes started on December 2 it was announced by M. E. Lord, manager of the Fort Wayne Works of the General Electric Company.

The building, to be erected by Stone and Webster Engineering Corporation of Boston, Massachusetts, as a Defense Plant Corporation project, is expected to be finished by July 1. It will be one story high, 800 ft. long, 700 ft. wide, and have 560,000 sq. ft. of floor space. The building will cost $8,000,000 and machinery and equipment to be installed will cost more than $16,000,000. Approximately 4000 employees will be required at peak production.

At present General Electric is manufacturing the turbo-supercharger, a vital part of high-flying airplanes, and bombers, at Lynn, Massachusetts, and a $5,000,000 factory for similar manufacture has recently been completed at Everett, Massachusetts.

PORTABLE UNIT DEMAGNETIZES TOOLS

▲ A new, powerful, portable demagnetizer is announced by the Ideal Commutator Dresser Company, 1045 Park Avenue, Sycamore, Illinois.

It quickly demagnetizes tools, drills, punches, dies, and work held in magnetic chucks. Abrasive particles such as metallic dust, flakes, fine chips, etc., that simply can't be wiped off clean with a rag are easily removed after a single pass across the magnetic poles.

After the tool or part is demagnetized, it can be laid on a bench or shelf without again attracting nearby metals.

Large parts may be demagnetized in a similar manner, except that the demagnetizer, which is light in weight and easy to handle, is moved over the heavy, bulky work.

If tools are not demagnetized, they are bound to attract small and sometimes imperceptible metallic chips and dust. These abrasive particles, that cling to the magnetized cutting edge, rub constantly between the tool and work, causing the tool to bind or heat and dull quickly. That's why demagnetized tools stay sharp longer. They get off to a fresh cutting start—cut faster and are more accurate.

The Ideal demagnetizer has an indicating light which shows when current is on. Has all metal, streamlined case. Rating, 115 volt, 50-60 cycle (5 amperes). Other voltages and frequencies available. Size only 5¼ in. x 10½ in. x 4½ in. Weight 17 lb.

CATALOG DESCRIBES CARBIDE TOOLS

▲ As a result of the tremendous demand for Kennametal steel-cutting carbide tools throughout the world, the new Kennametal Catalog No. 42 has just been reprinted by the United States Steel Export Company, 30 Church Street, New York—foreign agents for Kennametal tools and blanks, in all countries exclusive of Canada and Great Britain.

Although Kennametal has only been on the market three years, more than a ton of these tool tips were recently shipped to Australia (800 lb. going by clipper ship), indicating its wide acceptance.

Kennametal Tools and Manufacturing Company, Ltd., Canadian agents in Hamilton, Ontario, have also reprinted this catalog.

Kennametal tools and blanks are manufactured by McKenna Metals Company, Latrobe, Pennsylvania.

NICKEL PRODUCTION AT ALL-TIME HIGH

▲ World nickel production and consumption in 1941 were at an all-time high. The sharp increase in demand arising from the joint British, Canadian and United States war effort required nickel production far beyond anything experienced in the past.

The United States consumed over two-thirds of the world's total nickel output in 1941, as contrasted with an average annual consumption of about one-third during recent years. It is estimated that steel mills in the United States are currently consuming approximately 70 per cent of the refined nickel imported into that country. Of the remaining 30 per cent, foundries are taking 7.3 per cent, brass mills 6.5 per cent, heat resisting and electrical resistance alloys 4.6 per cent, electroplaters 2.5 per cent, and the balance is required for rolled nickel and high nickel alloys and a variety of other products.

All mines and smelters of International Nickel operated at capacity throughout the year and the production rate has been raised in an endeavor to satisfy the unprecedented war-time demands for nickel. To increase its nickel production by 50,000,000 lb. annually over its 1940 rate and thus make available a substantial additional supply, the Company has undertaken a production expansion program to be completed in 1943 involving an expenditure of approximately $35,000,000.

BETTER RESULTS IN FURNACE OPERATION with HAYS INSTRUMENTS

SUPERSENSITIVE DRAFT RECORDERS SERIES "OT" You can make sure of BALANCED Draft Conditions in Open Hearths, Soaking Pits, Annealing Furnaces and Slag Mills by installing Hays Series OT Recorders.

These instruments give a correct indication of furnace atmospheres and a permanent record of pressures and drafts at vital points as guides for most effective operation.

Write for descriptive bulletin.

PATENTS PENDING. This gage is calibrated in terms of air and gas flow—but may be used for any two flows for which the instrument is calibrated.

HAYS VISIO-RATIO GAGE

3 INSTRUMENTS IN 1 . . . 1. Air-Flow Indicator . . . 2. Fuel-Flow Indicator . . . 3. Ratio Indicator. Shows at a glance the exact ratio existing between flow of gas or flow of oil or other measurable fluid: pressure, draft, suction, temperature (up to 1000° F.) speed in R.P.M. or inches per minute, position, level and others.

This newest Hays instrument is a guide to higher manufacturing efficiency, increased production, better products and lower costs. It shows relations at a glance and eliminates the necessity of making calculations to determine excess or deficiency.

If you will write us, stating the conditions, we will tell you exactly how the Hays Visio-Ratio Gage can be applied to your problem.

The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

The prices of nickel in Canada and the United States remained unchanged during 1941 at figures prevailing for over fifteen years. No price revision is anticipated in the immediate future.

Coincident with the diversion of raw materials from non-essential uses, additional measures of conservation were undertaken by the British, Canadian and United States Governments so as to insure adequate nickel deliveries to the war industries of these countries. According to present estimates, over 90 per cent of the nickel now available is being used to fill high priority war orders.

Shortly after United States consumption of nickel was placed under priority control by the Office of Production Management at Washington, International Nickel publicly offered the services of its technical staff to peace-time consumers in the United States. This was done to assist them in finding substitute materials and to aid in solving problems caused by the diversion of nickel to war industries.

Since the conclusion of the first World War, rolling mills, adequately equipped with the latest types of machinery, have been constructed by International Nickel in Great Britain and the United States. These modern facilities, supported by intensive research efforts in metallurgy and metal markets, have established many new alloys of nickel and types of monel which have become standard materials of construction in many industries. Concurrently, development and research activities on the part of users of nickel have developed new nickel applications, many of which for the time being must remain inactive because of priorities and the requirements of nickel for war.

NEW LITERATURE

▲ Publication GED-972A, recently issued by the General Electric Company, is an attractive eight-page booklet giving the complete story on Thy-mo-trol, the new G-E electronic control system for the operation of d-c. motors from a-c. lines.

Containing photographs, a simplified chart, and diagrams, the publication tells how the Thy-mo-trol system not only provides stepless, wide-range speed control, but also performs the additional functions of starting, accelerating, protecting, and stopping d-c. motors.

The single-dial speed control is discussed, and four typical Thy-mo-trol applications are given to round out the booklet.

▲ A new catalog, "Micromax Telemetering and Totalizing Recorders for Electric Power"—just issued by Leeds and Northrup Company—shows how not only utility systems and stations but industrial power plants and power purchasers are effecting operating economies by indicating and recording load continuously and automatically. Well illustrated, this 28 page publication describes equipment which can telemeter over practically any distance—can totalize the load of almost any number and any combination of generators, stations, tie lines, etc.—is easily adaptable to either simple or complex requirements.

Even in Winter
Hot Spots Slow Up
Production . .

TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 inch sizes.

Keep Workmen Cool
with
TRUFLO FANS

During even the coldest weather there are "hot spots" in many mills—places where heat and foul air play hob with production.

Truflo Fans can keep your men on their toes all year around. All Truflo Fans are designed and built to put fresh, cool air exactly where it is needed. Perfectly balanced blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

There is a type of Truflo Fan for every cooling and ventilating use. Write for literature on any of the following kinds:

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO PORTABLE
COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

TRUFLO FAN COMPANY
554 MAIN ST., HARMONY, PA.

Whether you are concerned with the generation, the transmission or simply the use of electric power, we believe you will find this new catalog of practical value. Copies are now ready. To receive one, ask Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania, for Catalog N-58-161.

▲ A new twelve-page bulletin entitled "Meehanite Castings in Defense Work" has just been published by the Meehanite Research Institute of America, Inc., 311 Ross Street, Pittsburgh, Pennsylvania. The booklet describes and illustrates Meehanite castings used in aircraft manufacture, gun and shell manufacture, machine tool castings, and radio, marine, truck, and steel mill equipment.

A copy will be sent free upon request.

▲ General catalog No. 1100, recently published by the Pyle-National Company, Chicago, Illinois, contains complete listings of Pylet conduit fittings, plugs and receptacles. The book also contains general information as to portable cord and cable dimensions, allowable conduit sizes, etc., and is completely indexed.

▲ Koppers Company, Tar and Chemical division, has just published an eight-page folder which summarizes all of Koppers' important products, plants and services.

The list ranges from Koppers coals and coke to light oil plants and purification systems; from valves, castings, forgings, couplings and piston rings to roofing, tar-base paints, and pressure-treated timber products.

Two pages are devoted to the uses, technical description and characteristics of tar acids, tar acid oils, and coal tar solvents.

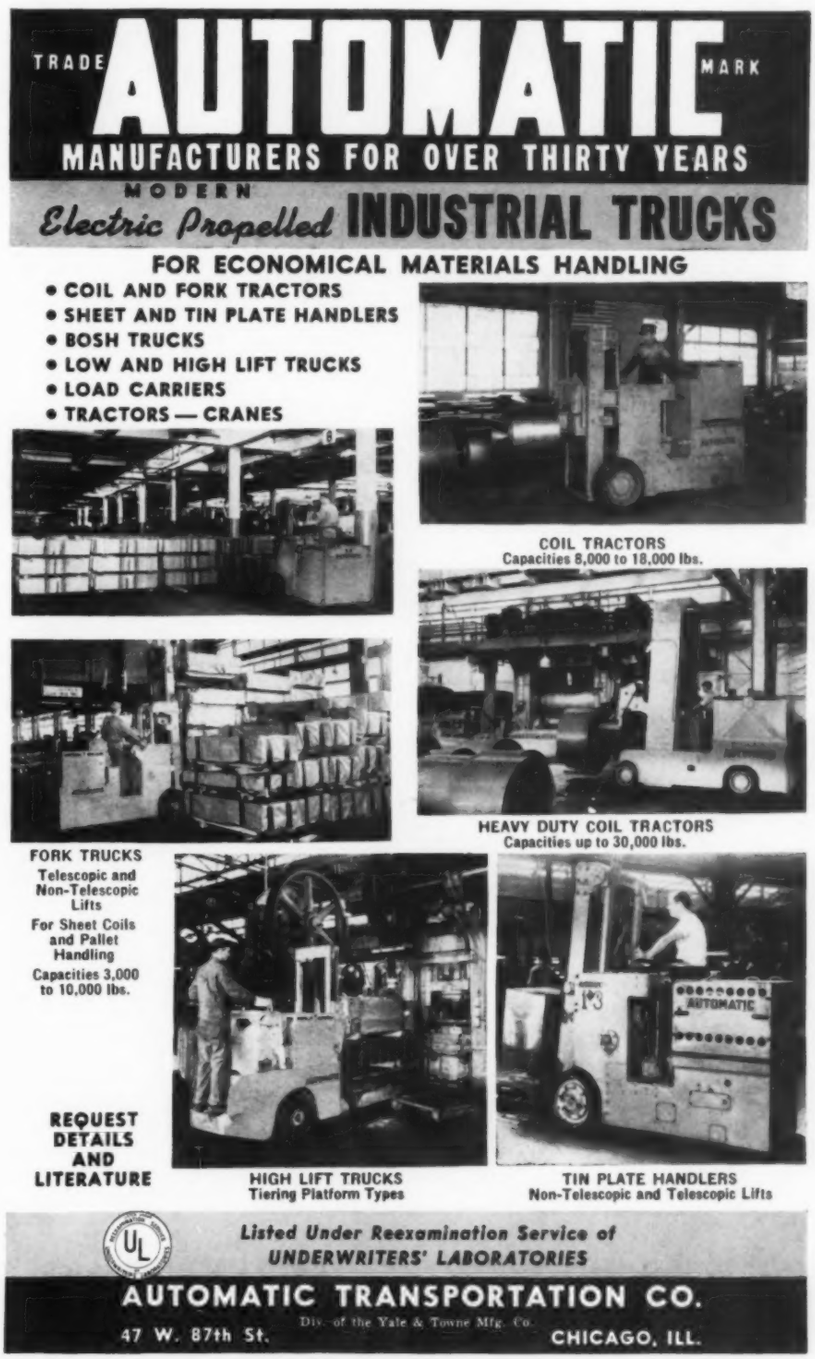
▲ A new 4-page bulletin, "Hand Pumps," No. 240-A, issued by the Watson-Stillman Company, Roselle, New Jersey, describes hand operated, high pressure pumps for testing purposes and for operating hydraulic jacks and other small hydraulic tools.

Pressure capacities of the pumps shown range from 1500 to 30,000 lb. per sq. in. Ten different types of pumps are illustrated, including single and double plunger types, the latter for use where high speed of initial movement is required. Construction features of each are described.

▲ The Brown Instrument Company, Philadelphia, Pennsylvania, has just issued a new catalog No. 8301—"Industrial Control Devices—Products of Minneapolis-Honeywell Regulator Company."

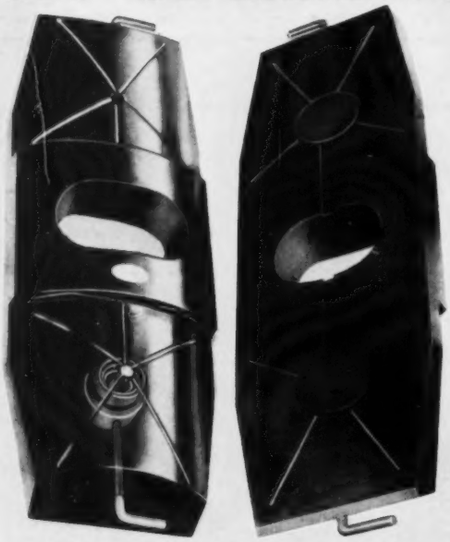
This new 56 page, large size, two color catalog is a comprehensive source of information for all interested in learning how production may be increased, costs lowered and product quality improved through the judicious use of automatic control of industrial processes.

It has been written to be readily understood by the engineer and layman alike. The first few pages of the book contain a primer of automatic control. The three classes of automatic control, *i.e.*, electric, pneumatic and combined electric and pneumatic are fully described. Definitions of the various technical terms used in the descriptions are given.



LEADERS

IN SPEEDING UP PRODUCTION



GATKE SELF-ALYN SLIPPERS Last 10 times longer. Eliminate Socket Scoring and Wear and avoid costly machine shop work. End destructive vibration. Stop pounding noises. Prevent Grease slinging. Made to fit without machining for all sizes and types of Universal Couplings.

In meeting the ever increasing pressure for greater and greater output GATKE Fabric Bearings have proved an ace in the hole for many mills.

TREMENDOUS WEAR LIFE—saves over 90% of bearing replacement time.

LOWEST FRICTION—effects enormous saving in power—permits greater reduction per pass.

LOW STARTING FRICTION due to GATKE patented, self-lubricating feature.

ELIMINATION OF HOT NECKS AND NECK SCORING—avoids delays and costly machine shop work.

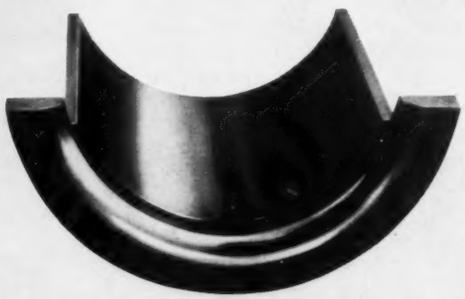
ACCURATE HOLDING OF GAUGE — eliminates screw-down adjustments and "off gauge" losses.

MOULDED ACCURATELY TO SIZE for installation without machining.

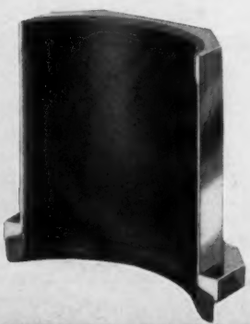
Hundreds of reports in GATKE files show phenomenal economies on the widest range of tough rolling mill service.

Send details on your tough bearing jobs for particulars.

On spindle carriers GATKE Bearings are lasting 10 to 20 times longer—eliminate scoring — reduce friction — save power.



GATKE Grease-Lubricated Crane Bearings give wonderful service. Outlast metal bearings many times over. Low starting friction —about 50% less than metal. Require less frequent lubrication. Use GATKE Crane Bearings for your next replacement. You'll see why so many cranes have GATKE Bearings.



250,000 tons from GATKE Fabric Bearings, compared with 5,000 tons from metal bearings. 76% Saving in Power. 400% greater mill capacity. Much greater reduction per pass. Closer gauge tolerances. These are some of the benefits experienced by users of GATKE Roll Neck Bearings (Illustration shows GATKE Bearing for 30" diameter neck.)

GATKE CORPORATION 228 N. La Salle St., CHICAGO, ILL.

Packed Full of Service

Type TLS
Track Type
Limit Switch

Type TLSF
Track Type Limit Switch

YOU bet these "3C" Bulletin 102 Heavy Duty Snap Action Track Type and Pilot Circuit Crane Hook Limit Switches are packed full of service.

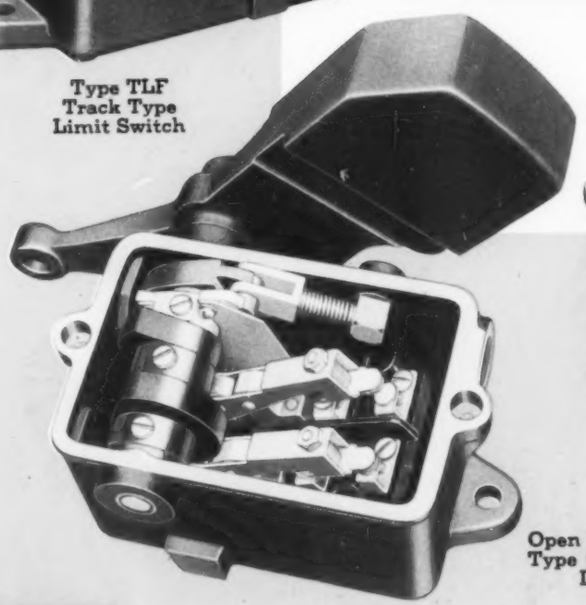
Cast iron enclosures (gasketing for NEMA IC 50-28 Dust Tight applications available); husky steel shaft in oilless bearings; Bakelite Cams operate contact fingers; double break silver-to-silver contacts; screw driver adjustments permit independent change of any pole from N.O. to N.C. and vice versa; cadmium plated operating arms—all these and many other features give service in heavy duty operation.

Ask for fully descriptive "3C" Bulletin 102, Type TL.

Type TLOF
Track Type
Limit Switch

Type TLF
Track Type
Limit Switch

Open View Type TLF
Bulletin 102
Limit Switch



Open View Bulletin 102
Type CHL Crane Hook
Limit Switch

Bulletin 102
Type CHL
Crane Hook
Limit Switch

OFFICES IN PRINCIPAL CITIES

THE CLARK CONTROLLER CO.

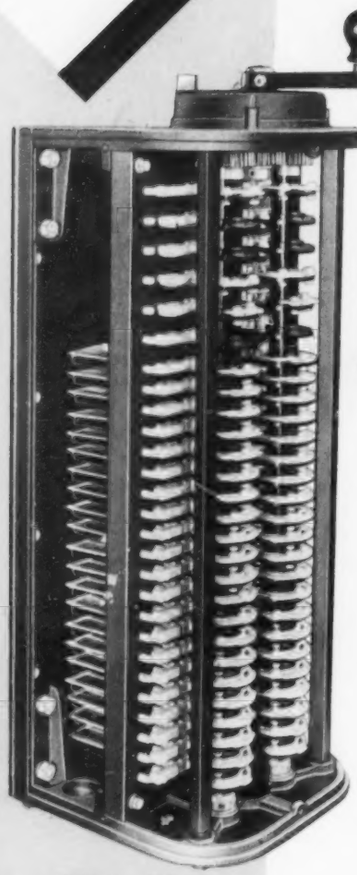
1146 EAST 152ND ST. CLEVELAND, OHIO

Related Design

A FEATURE OF "3C" CONTROL

this Finger Mechanism Fits an Entire Line of Devices

Open View
Track Type
Limit Switch



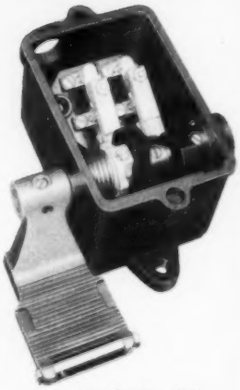
Bulletin 101
Combination Rubber Mill
Calender Master Switch
and Field Rheostat
Dual Type

THERE'S a strong family trait evident in all these "3C" devices.

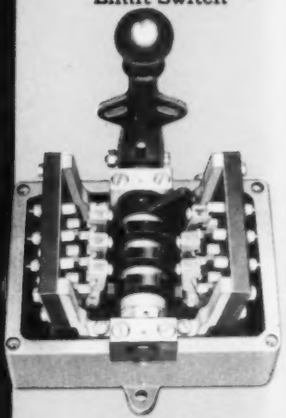
It's that FINGER CONTACT MECHANISM which is interchangeable in every one of these sturdy devices.

You can easily remove the entire mechanism; a slight twist of the fingers then releases the Contact Bar with its silver-to-silver contact tips, but the Pressure Spring is held securely in place. There's no groping in dark corners for springs—they're held in position.

By standardizing on "3C" Switches, you have less spare parts to stock; your maintenance problem is simpler; and these rugged "3C" devices deliver excellent service in heavy duty operation.



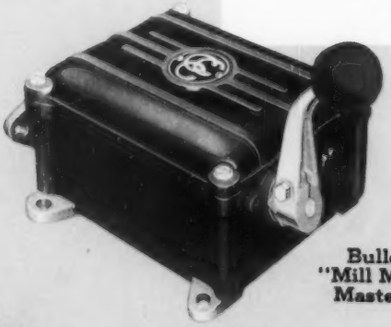
Bulletin 101
Foot Switch



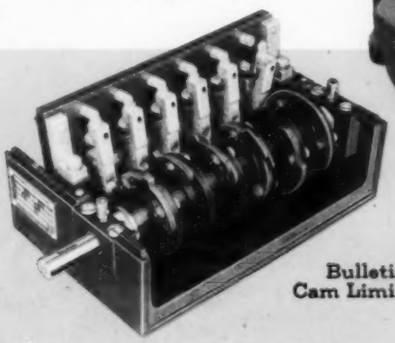
Open View
Bulletin 101
Mill Master Switch

Bulletin 102
Hatchway
Limit Switch

Crane Hook
Limit Switch



Bulletin 101
"Mill Master, Jr."
Master Switch



Bulletin 102
Cam Limit Switch

CONTINUE TO ROLL WITH CLARK CONTROL

THE CLARK CONTROLLER CO.

1146 EAST 152ND ST. CLEVELAND, OHIO

THIS TEST PROVES...

...YOU CAN DO THIS!

Rockbestos A.V.C. Boiler Room and Lighting Wire (Underwriters' and Nat. Elec. Code—Type AVA maximum operating temperature 110°C. (230°F.)

Rockbestos A.V.C. 600 Volt Power Cable (Underwriters' and Nat. Elec. Code—Type AVA maximum operating temperature 110°C. (230°F.)

Rockbestos A.V.C. 600 Volt Motor Lead Cable (Underwriters' and Nat. Elec. Code—Type AVA maximum operating temperature 110°C. (230°F.)

The blowtorch test proves that Rockbestos permanently insulated wires and cables are *more than fireproof!* It gives a visible demonstration of the fact that they are *inherently heatproof* and made to stand up in such applications as the Rockbestos-wired steam valve control room above where 180°F. is normal.

Some wires are flameproof for a limited period but are not fireproof or heat-resisting. Others are heat-resisting under limited operating temperatures but are not flameproof or fireproof. Rockbestos permanently insulated wires and cables take the blasting, red-hot flame of the torch without igniting or burning and the destructive drubbing of persistent high temperatures around boilers, furnaces, glass lehrs, rheostats, soaking pits and steel conveyors without drying out or becoming brittle, because they are *inherently heatproof, positively fireproof,* and resistant to alkalies, moisture, oil, grease and corrosive fumes as well.

If you want to keep your production *moving*... spot your trouble spots... anticipate your minimum footage requirements as far in advance as possible... and get ready to rewire with permanently insulated Rockbestos wire, cable or cord.

For a catalog and samples write to: Rockbestos Products Corporation, 825 Nicoll St., New Haven, Conn.

Also Refer to McGraw-Hill Electrical Buyers Reference

Anticipate Your Requirements!

TEN TESTED ROCKBESTOS VALUES that will pay you dividends

1. HEATPROOF
2. FIREPROOF
3. PERMANENT
4. Lower maintenance cost
5. Resists heat and vibration
6. Saves work
7. Oil, Grease and Moisture resistant
8. High overload capacity
9. Permanently flexible
10. Greater carrying capacity

New York . Buffalo . Cleveland . Detroit . Chicago . Pittsburgh . St. Louis . Los Angeles . San Francisco . Seattle . Portland, Ore.

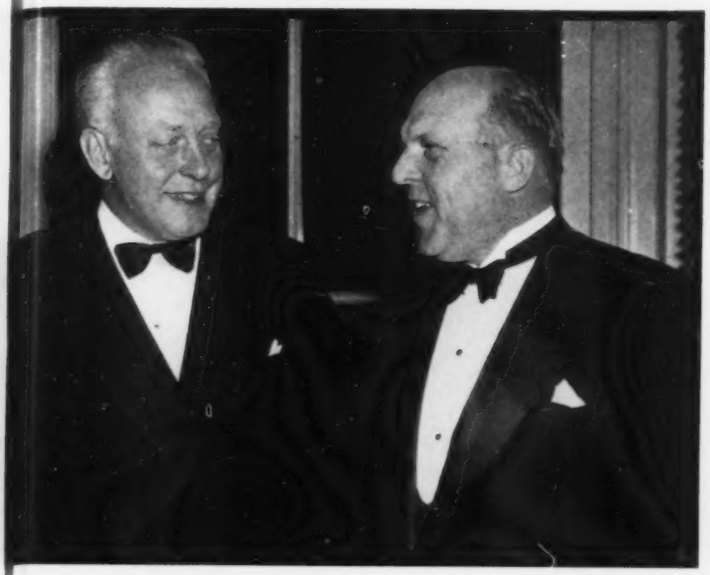
ROCKBESTOS — *the wire with permanent insulation*

Rockbestos All-Asbestos Power and Rheostat Cable — Underwriters' and National Electrical Code Type AI — one of 118 different permanently insulated wires

The NEWS *in* REVIEW

TWO PITTSBURGH PLANTS AWARDED NAVY "E" . . .

Heppenstall Company and the Carnegie-Illinois Steel Corporation were recently awarded the coveted Navy "E" and Ordnance Flag for excellence in fulfilling vital Navy contracts. Admiral William H. Standley (*below left*) congratulates William Fagan of O.H. No. 2, Homestead, on his good work in helping to turn out steel vital to defense, while H. G. McIlvried, superintendent, Homestead Works, looks on. More than 9000 Carnegie-Illinois employees attended evening ceremonies at the Hunt Armory, at which time J. L. Perry, president of Carnegie-Illinois, formally accepted the awards from Admiral Standley (*below right*). The United States Navy Band, passing in review at Heppenstall Plant (*above*) broke all precedent by appearing for the first time at a civilian function of this type.

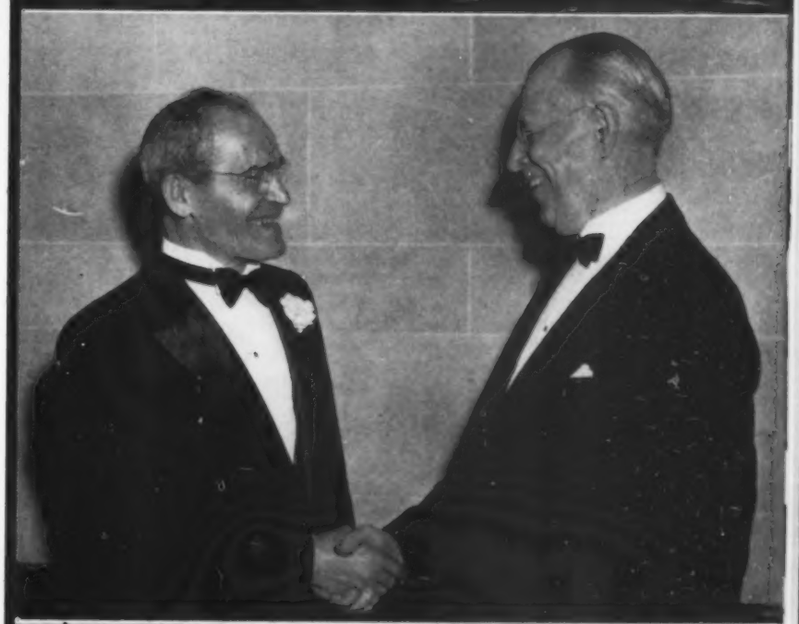


SPEAK AT CARNEGIE DAY DINNER

J. H. Kindelberger (*left*), president, North American Aviation, and R. J. Wean, president, Wean Engineering Company, Inc., were speaker and toastmaster respectively at the celebration of Andrew Carnegie's 106th birthday at Pittsburgh, Pennsylvania, November 25, with alumni of Carnegie Tech and numerous industrial leaders in attendance.

PENNSYLVANIA TRANSFORMER HAS NEW HOME . . .

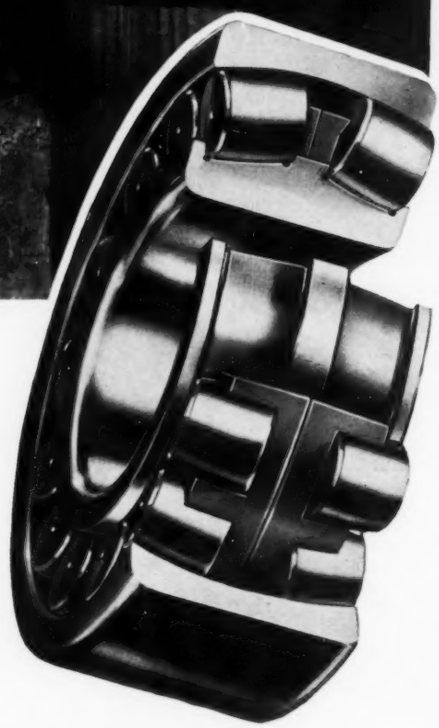
The town mansion (*upper right*) of the late B. F. Jones located at 808 Ridge Avenue, Pittsburgh, Pennsylvania, is now the business and sales headquarters of the Pennsylvania Transformer Company. (*center right*) Sam Horelick (*left*), president, was host to a group of industrial leaders at the formal opening, December 5, and is pictured receiving congratulations from W. E. Moore of Pittsburgh Lectromelt Furnace Corporation. (*below right*) John Follansbee, (*left*), and J. S. Murray, (*right*), were accompanied on a tour of the new quarters by W. E. Kerr, vice president of Pennsylvania Transformer.



CHEMICAL SHOW DRAWS 50,000 . . .

The more than 300 exhibits at the 18th Exposition of Chemical Industries, Grand Central Palace, New York, December 1-6, were viewed by more than 50,000 visitors one of whom is shown below with V. J. Nolan at the National Carbon booth.

Built by THE RELIANCE ELECTRIC & ENGINEERING COMPANY, *this 100 h.p., 300/1200 r.p.m. direct-current Type T Heavy Duty Motor is driving a flying shear in a sheet steel mill.*



Motors on SKF's

SAVE TIME ON DEFENSE

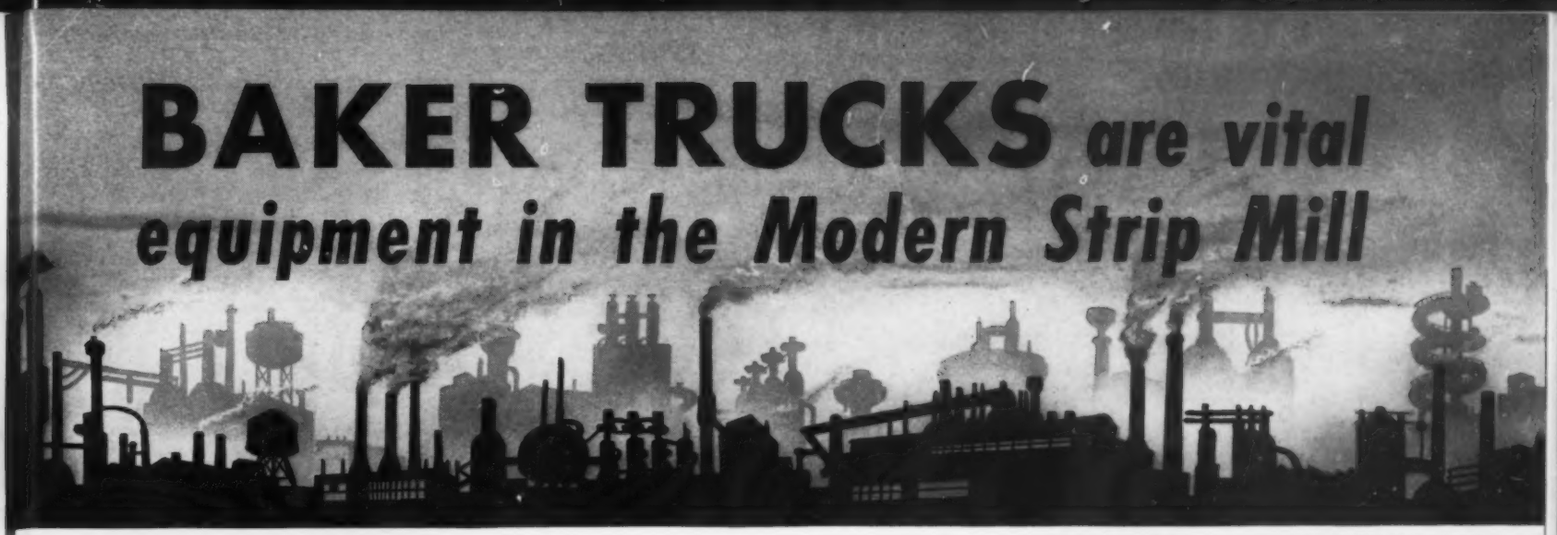
There's no time to waste on bearing trouble in the Steel Industry these days. Men and machines are working overtime to produce more steel for more guns, more shells, more airplanes, more battleships, more of everything. That's why so many motors are depending on SKF Bearings. SKF's hold the initial air gap permanently, lengthen motor life, increase torque—enable motors . . . and the machines they drive . . . to do a full day's work *every* day. In motors on the Defense jobs of Industry, Performance is a requisite invariably assured by SKF Bearings.

SKF INDUSTRIES, INC., FRONT ST. & ERIE AVE., PHILA., PA.

4946

ROLLER **SKF** BEARINGS

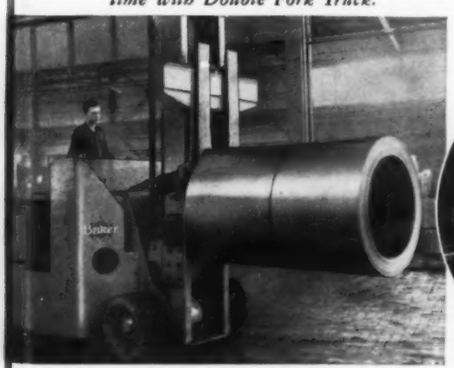
BAKER TRUCKS are vital equipment in the Modern Strip Mill



Baker Heavy Duty Ram Truck handling two 8000 lb. coils of strip.

Two of the fleet of Baker Trucks in the largest stainless mill.

Sheet steel or tin plate handled two loads at a time with Double Fork Truck.



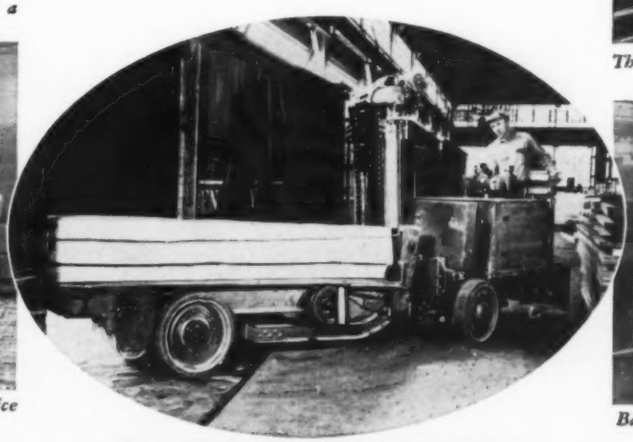
15,000 lb. capacity Baker Ram Truck in service at a large hot strip mill.

Power Industrial Trucks for materials handling are an integral factor in the production of Steel today, and Baker plays an important part in providing this necessary equipment.

Every large mill described in "The Modern Strip Mill," uses a fleet of Baker Trucks. These trucks are called on for a wide variety of services. In many cases difficult handling problems required special designs, which were worked out by Baker in cooperation with mill engineers.

Today the Baker plant is operating day and night to meet current demands. Every effort is being made to produce more trucks, so that Industry—and especially Steel—can produce more Defense Materials.

BAKER INDUSTRIAL TRUCK DIVISION
of THE BAKER-RAULANG COMPANY
2158 WEST 25th STREET • CLEVELAND, OHIO



Baker Articulated Sheet Handler loads 200 tons per hour—saves $4.30 per ton.

Ruggedness and maneuverability have made this 15,000 lb. capacity truck a favorite with steel men.

This Baker Fork Truck picks up six ton coils and up-ends them in transit.

This Baker Truck with swivel cut loading costs from $28.00 to $5.00 per car.

Baker Tractors move many tons of steel in single or multi-trailer trains.

Baker INDUSTRIAL TRUCKS

In Canada: Railway and Power Engineering Corporation, Ltd.

YOURS *for the Asking!*

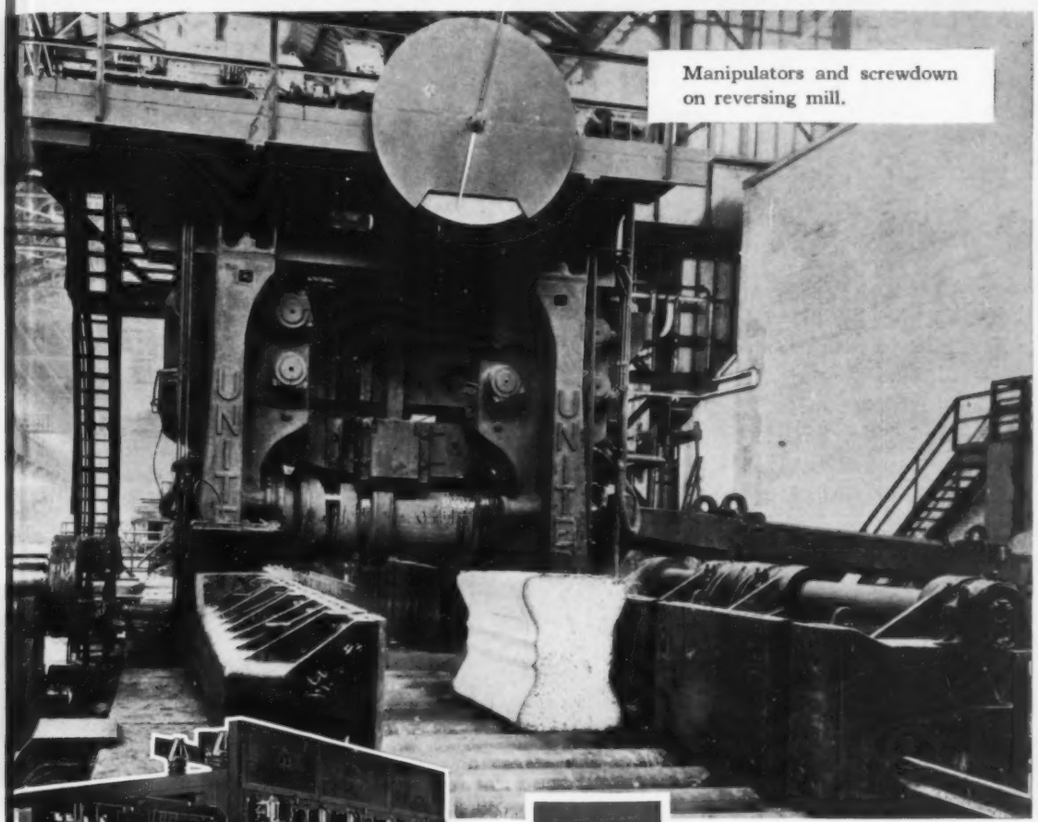
Yours for the asking is *Modern Material Handling,* 1941 edition, a 24-page 8½ x 11 illustrated booklet giving you much useful information on the tractor-trailer system, the skid-lift-truck system, the pallet-fork-truck system and various special industrial-truck handling systems. Tells you how to judge which one or combination of these systems is best adapted to your handling operations.

Also included is a condensed description of the advantages of steel-alkaline storage batteries as industrial-truck power units, useful recommendations as to selection of batteries for continuous 24-hour-a-day operation, electrical data and dimensions of trays, steel cradles, and demountable steel boxes for batteries ranging from below 10 kwh to above 60 kwh of rated capacity.

This booklet is useful not only to users of industrial trucks but also to those who are considering the installation of their first truck. Address Edison Storage Battery Division of Thomas A. Edison, Inc., West Orange, N. J.

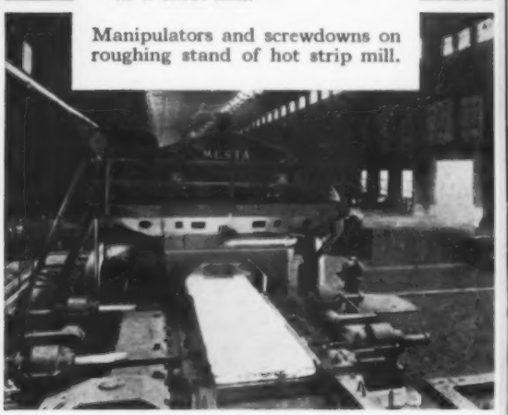
Edison
STEEL *Alkaline* BATTERIES

WESTINGHOUSE DEVELOPMENTS SPEED STEEL PRODUCTION

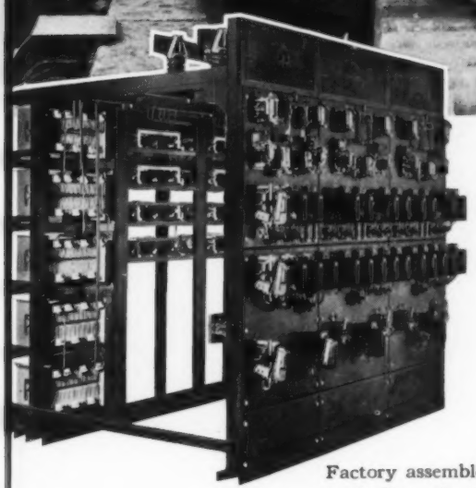


Manipulators and screwdown on reversing mill.

Roller level and cutting line in a sheet mill.



Manipulators and screwdowns on roughing stand of hot strip mill.



Factory assembled d-c Magnetic controller—class 9500.

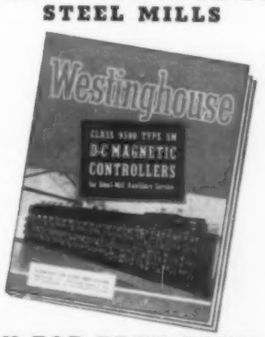
Factory assembled controllers get into production faster

D-C Magnetic Controllers are designed, assembled, wired, tested and shipped as a complete unit. Installation consists merely of completing incoming line and outgoing motor and control connections. Unit construction also provides easier maintenance and quick interchangeability of parts.

These controllers follow a composite design developed from close association of Westinghouse with machine builders and mill operators in solving production problems. That's why builders and operators are turning to Westinghouse for this type of equipment.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
EAST PITTSBURGH, PA.

NEW
CONTROLLER BOOK FOR STEEL MILLS



ASK FOR FREE COPY...

Shows how Westinghouse factory-assembled controllers save time and money—shows typical circuit diagrams for steel mill applications.

Westinghouse

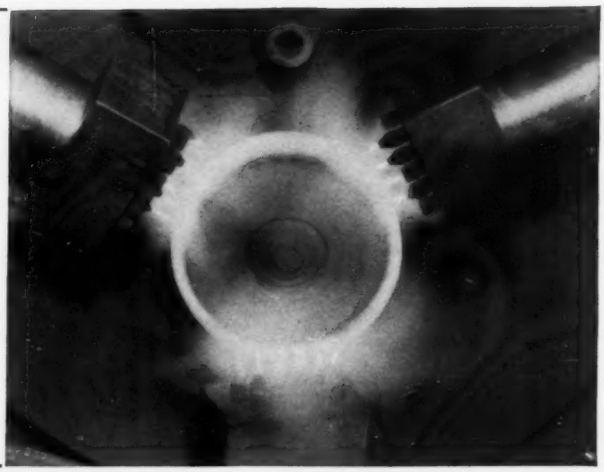
J-94445

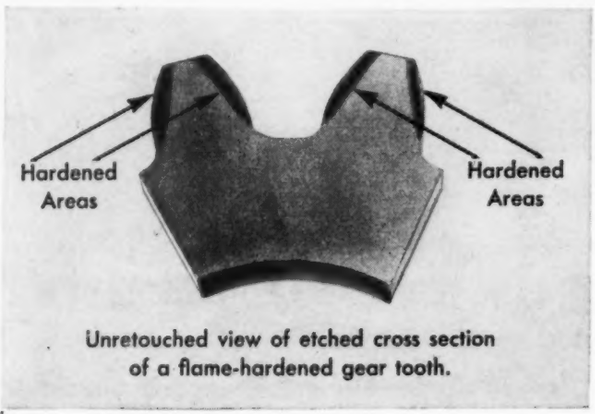
TIME-SAVER FOR THE STEEL INDUSTRY

OXY-ACETYLENE FLAME-HARDENING makes wearing parts last longer . . .

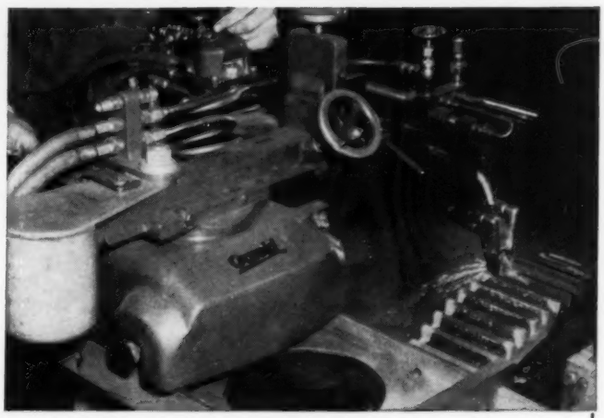
1. What it is and how it's done

Oxy-acetylene flame-hardening imparts a hard case to wearing parts to make them last longer. This is done by heating the area to be hardened with oxy-acetylene flames, and then quenching with water or oil. Commonly used steels and high-tensile cast iron can be flame-hardened successfully. Small areas can be hardened by the "spot" method, using a hand welding blowpipe. Larger areas are usually hardened by mechanized equipment, using the "progressive" method or—as shown in the illustration at the right—the "spinning" method.





Unretouched view of etched cross section of a flame-hardened gear tooth.



2. What its advantages are

In many cases, oxy-acetylene flame-hardening is not only the best method, but the *only* practical method. Some of its advantages are:

- Parts of any size or shape can be hardened.
- There is no appreciable distortion.
- Toughness of the core is unaffected.
- Chemical composition of the metal is unchanged.
- Penetration can be closely controlled.
- The hardened area does not spall off.
- It permits use of cheaper base metals.
- Only a moderate equipment investment is required.

3. Typical parts being hardened

In the illustration above, Oxweld flame-hardening equipment is being used to impart a hard case to the teeth of a crane gear — at only the points where wear occurs. A few of the many other parts which are hardened—or fabricated—with the help of this oxy-acetylene process are:

Sprockets	Cams	Piston Rods
Dies	Crane Wheels	Pump Plungers
Sheave Wheels	Bearing Raceways	Crossheads
Shear Blades	Shafts	Saw Blades

Linde can supply the gases, the apparatus, and help in using flame-hardening. If you are interested in giving longer life to wearing parts, *talk it over with Linde!*

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

UCC

General Office: New York, N. Y. Offices in Principal Cities
In Canada: Dominion Oxygen Company, Limited, Toronto

LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD APPARATUS . . . OXWELD SUPPLIES

The words "Linde," "Prest-O-Lite," "Union," "Oxweld," "Purox," and "Prest-O-Weld" are trade-marks of Units of Union Carbide and Carbon Corporation.

FROM THE TECHNICAL LIBRARY OF KOPPERS

...STRY THAT SERVES ALL INDUSTRY

...W TO SOLVE SHAFT ...ALIGNMENT PROBLEMS

KOPPERS ...LL-IRON GATE VALVES

...TO TRANSPORT MOLTEN METAL AT LOW COST

KOPPERS COAL FOR COKE PLANTS

...W TO REMOVE AND RECOVER H_2S

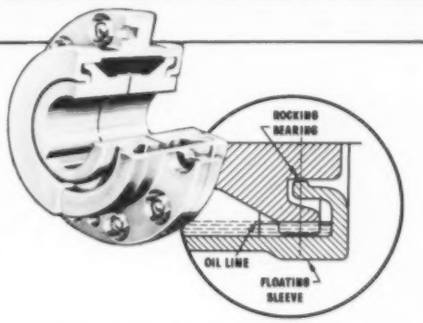
It's the Super— he says to ★!?★ with cheap couplings . . . he wants "FAST'S"

For a proven method of avoiding operating troubles—specify *genuine* Fast's Couplings on the new machinery you purchase.

KOPPERS COMPANY

BARTLETT HAYWARD DIVISION

BALTIMORE, MARYLAND



These views show the exclusive design features of Fast's Couplings. The load-carrying surfaces are protected against wear by a positive film of oil. This oil is kept permanently clean by rocking bearings, which make precise metal-to-metal contact and are located in the one position where they form permanent dust and moisture-proof seals. Only *genuine* Fast's Couplings have these important advantages.

a KOPPERS product

Fill out and mail

KOPPERS COMPANY
7328 Koppers Bldg., (19) Pittsburgh, Pa.

Please send me the literature checked:

Name.....

Title.....

Company.....

Address.....

- ☐ "Fast's Self-aligning Couplings"
- ☐ "Koppers All-Iron Gate Valves"
- ☐ "Hot Metal Transfer Cars"
- ☐ "Koppers Coal for Coke Plants"
- ☐ "How to Order Piston Rings"
- ☐ "Piston Rings for Compressors"
- ☐ "Piston Rings for Diesel Engines"
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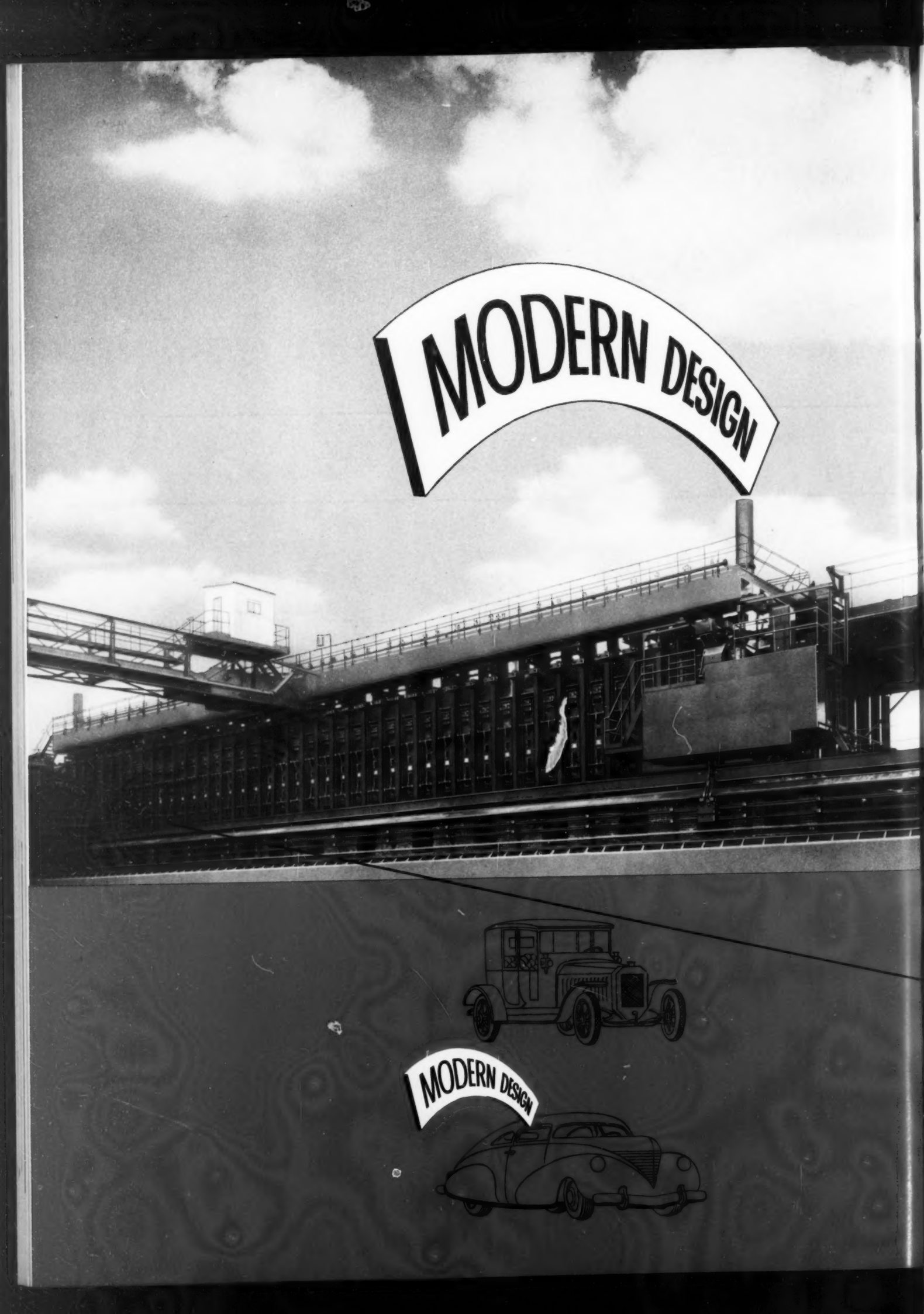
MODERN DESIGN
MODERN DESIGN

Koppers

Modern Coke Oven Design

best meets *National Defense Needs*

Fundamental developments recently introduced in the coal gas and lean gas heating methods of Koppers-Becker Coke Ovens have brought about great improvements in operating results, such as:

1. **Production of more coke and by-products per oven**
2. **Greatest uniformity of heating of the coke**
3. **Lower underfiring requirements**
4. **Maximum safety in operation due to lower flue temperatures**
5. **Greater flexibility in the use of various heating gases**
6. **Elimination of carbon in masonry fuel gas ducts and, therefore, elimination of the conventional decarbonizing practice**
7. **Elimination of deposits of any kind in the heating gas regulating orifices and, therefore, elimination of all cleaning labor**
8. **Lower operating and maintenance costs**

Ovens of this type are now in operation at:

1. The American Rolling Mill Company at Hamilton, Ohio
2. Citizens Gas and Coke Utility, Indianapolis, Indiana
3. Connecticut Coke Company, New Haven, Connecticut
4. Bethlehem Steel Company, Sparrows Point, Maryland

Ovens of this type are under construction at:

1. Weirton Steel Company, Weirton, West Virginia
2. Monessen Coke and Chemical Company, Monessen, Pennsylvania (Subsidiary of Pittsburgh Steel Co.)
3. Philadelphia Electric Company, Chester, Pennsylvania
4. Brazilian National Steel Company, Rio de Janeiro, Brazil, S.A.

No steel company can afford to build new coke ovens without learning about these new developments.

KOPPERS COMPANY, Pittsburgh, Pa.

oppers has developed a large number of technical olders on its products and services. Send the coupon for ny in which you are interested:

- ☐ **"Flow diagram on the Hot Artification Process for Sulphur Recovery"**
- ☐ **"Seaboard Gas Purification"**
- ☐ **"Light Oil Refining"**
- ☐ **"Fast's Couplings"**
- ☐ **"Hot Metal Transfer Cars"**
- ☐ **"DHS Bronze for the Steel Plant"**
- ☐ **"Locomotive Cylinder and Valve Packing"**
- ☐ **"Piston Rings for Compressors"**
- ☐ **"Coal Tar Roofing Specifications"**
- ☐ **"Membrane Waterproofing Specifications"**
- ☐ **"Coal for Coke Plants"**

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Title.....

Company.....

Address.....

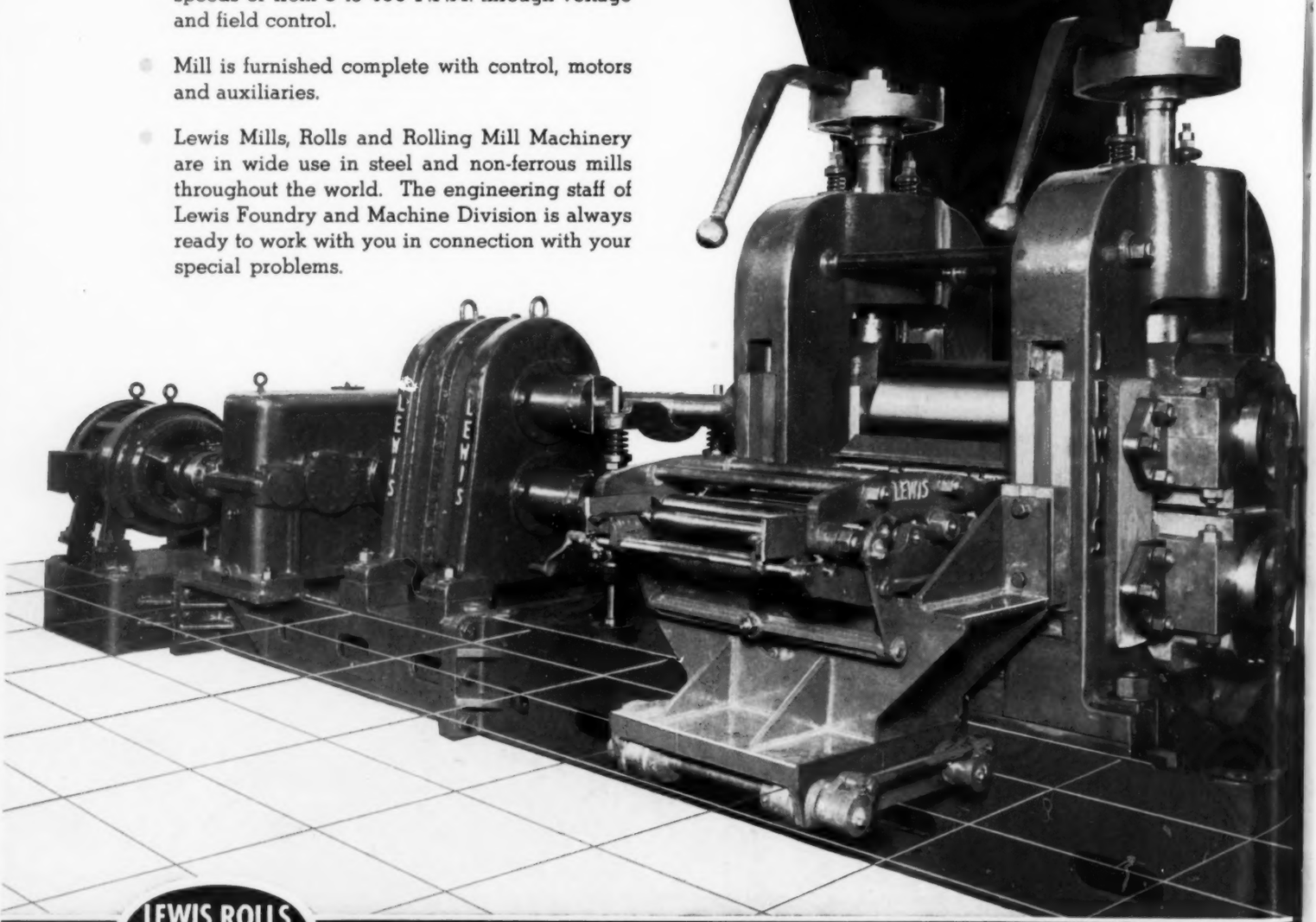
HIGH PRESSURE ROLLING WITH LESS THAN .0001" VARIATION OF GAUGE

feature this new—

LEWIS NON-FERROUS PRECISION MILL

Features of this new mill are—

- Automatic sticker and holdback arrangement.
- Clamshell roller wrapping mechanism.
- New water control mechanism on roll necks equipped with gravity oil feed for low velocity lubricant permitting the rolling of thin materials under extremely high pressure. The maximum variation of gauge is less than .0001".
- Synchronization of reel and mill motors for speeds of from 6 to 400 F.P.M. through voltage and field control.
- Mill is furnished complete with control, motors and auxiliaries.
- Lewis Mills, Rolls and Rolling Mill Machinery are in wide use in steel and non-ferrous mills throughout the world. The engineering staff of Lewis Foundry and Machine Division is always ready to work with you in connection with your special problems.



LEWIS ROLLS step up tonnage

LEWIS FOUNDRY & MACHINE

DIVISION OF BLAW-KNOX CO.

PITTSBURGH PA

"SO I TOLD THEM JUST WHAT WE NEEDED, MORE HARDNESS AT THE BOTTOM OF THE PASS . . ."
"YES, I KNOW! YOUR HEADACHE WAS OVER JUST LIKE MINE THE FIRST TIME I TRIED BIRDSBORO'S INDIVIDUALIZED ROLL SERVICE"*

* *For details of our service, write or phone our main office.*

BUILDERS OF
ROLLS • HYDRAULIC PRESSES
MILL EQUIPMENT
SPECIAL MACHINERY
CRUSHING MACHINERY

BIRDSBORO ROLLS

BIRDSBORO STEEL FOUNDRY AND MACHINE COMPANY . . . PLANTS AT BIRDSBORO AND READING, PA.

FAMOUS AMERICAN FIRSTS

FRANKLIN'S LIGHTNING ROD 1752
SPEER Electro-Graphitic Brush grades E-23 and E-24, correctly chosen and applied, meet the requirements of most industrial motors.
E-23
E-24
They are available also as Multiflex brushes offering special advantages in many cases. Write for SPEER Brush Catalog showing complete line and giving detailed specifications.
These SPEER Brushes for most applications.

Worth waiting for

In common with manufacturers generally, government orders, priorities and allocations govern the speed with which we can supply our customers with Speer brushes.

In spite of materially enlarged plants, equipment and personnel, some of our customers unable to secure high priority ratings or special allocations have been obliged to wait a few extra days for their brushes.

It is gratifying to find that so many are willing to wait this short time for brushes whose worth they know, rather than to experiment with something else.

Speer facilities and abilities assure as prompt a brush service as is available anywhere. So—may we suggest to those whose priorities do not permit first preference, that orders be placed just a little earlier than in the past. While National Defense must come first, we still solicit and acknowledge the good-will and patronage of our customers who have made the Speer Carbon Company what it is today.

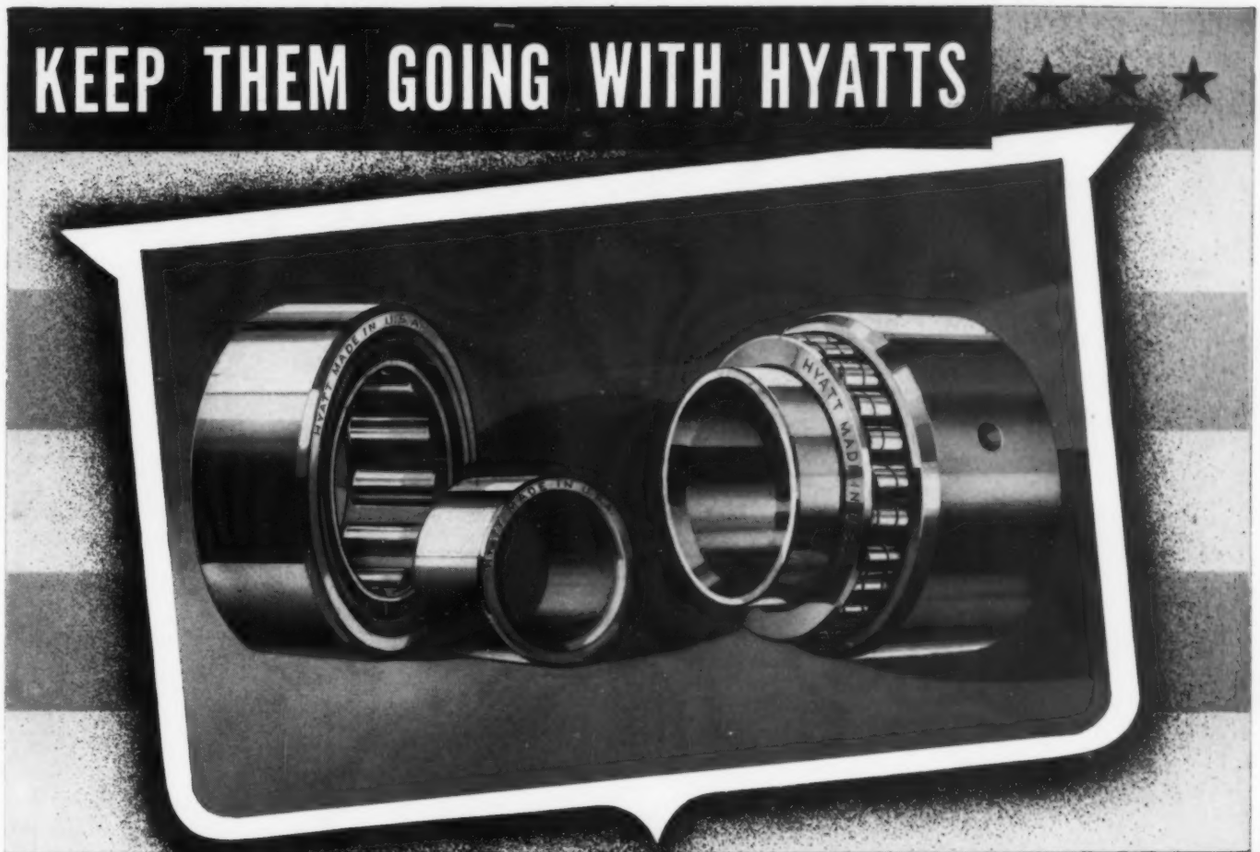
By placing your orders earlier you will be sure of getting the Speer brushes you have tested and found satisfactory. Your choice will be the logical outcome of the more than forty years of specialization in commutation engineering that has made Speer Brushes famous—that is now putting them, in unprecedented volume, into defense material and into the equipment for producing it.

SPEER CARBON CO. SCC

ST. MARYS, PA.

902.A

KEEP THEM GOING WITH HYATTS

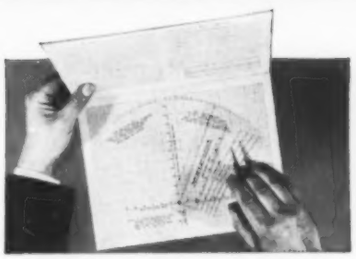


NO MATTER WHAT THE APPLICATION

Precision built... great in capacity... Hyatts are helping to lighten the loads of all mechanized defense equipment.

Meanwhile, Hyatts still are serving in their regular, and now more essential than ever, role of keeping free from bearing wear and care the machinery which produces this defense equipment.

Therefore remember, today as always, that where the loads are heavy and the going is tough you can depend on Hyatt Roller Bearings for any application.



FREE TO MACHINE DESIGNERS

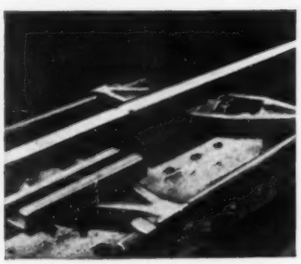
HYATT GEAR THRUST CALCULATOR —valuable timesaver for designers and engineers. Request in writing on your company letterhead—address Sales Engineering Department, Hyatt Bearings Division, General Motors Sales Corporation, Harrison, N. J.

HYATT

ROLLER BEARINGS

QUIET

4 STEPS
to end crane runway rail troubles



1.

Clamps in position

2.

Applying molds

Thermit welding for the repair of rolls, pinions, crank shafts and other heavy parts is standard practice in most steel mills. Weeks of valuable production time are thus gained and savings run into thousands of dollars.

Send for 30 page booklet, "Thermit Welding" which tells how you can use this process to great advantage in your mill.

Here you see the Thermit process at work, welding a crane runway rail in a large Pittsburgh plant.

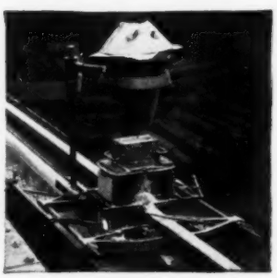
This company is one of many prominent steel mills which have discovered the economy of Thermit welding crane runway track.

The total elimination of rail joints permits smooth travel of the crane over the continuous track, reducing wear and tear on crane and crane structure, and greatly lengthening the life of the rails. There are no more battered rail ends and, of course, joint maintenance is a thing of the past.

Look into Thermit welding of *your* crane runway rails. Rails may be welded on the girder or on the mill floor and hoisted up afterwards.

Preheating. Weld is poured immediately after

3.



4.

Completed weld

Industry's Master Maintenance Tool

THERMIT ★ WELDING

METAL & THERMIT CORPORATION 120 BROADWAY, NEW YORK

ALBANY • CHICAGO • PITTSBURGH • SO. SAN FRANCISCO • TORONTO

FOR SPEEDIER, LOWER COST ARC WELDING INVESTIGATE MUREX ELECTRODES

CARBON *Mold Plugs*

FOR STEEL INGOT MOLDS

OTHER "NATIONAL" CARBON AND GRAPHITE PRODUCTS OF VALUE TO THE IRON AND STEEL INDUSTRY

Carbon Stopper Heads

• • •

Carbon and Graphite Brick for lining pickling tanks and desulphurizing ladles

• • •

Carbon and Graphite Tile, Blocks, Beams and other Structural Shapes

• • •

Carbon, Graphite and "Karbate" Pipe, Valves and Fittings for heating pickling solutions and for other uses in contact with corrosive materials

• • •

Graphite Powder for lubrication

• • •

The words "National" and "Karbate" are trade-marks of National Carbon Company, Inc.

THE USE OF "NATIONAL" CARBON MOLD PLUGS

- eliminates ceramic inclusions.
- prevents sticking of plug to ingot.
- prevents contamination of scrap from cropped ingot ends.

EACH CARBON MOLD PLUG CAN BE USED FOR SEVERAL POURINGS

STANDARD SIZES: $5\frac{13}{16}$" to $5\frac{1}{4}$" diameter by 3" long.
$5\frac{1}{8}$" to $5\frac{5}{16}$" diameter by 3" long.

Other sizes will be made to order on purchaser's specifications.

Write FOR COMPLETE INFORMATION ON THE PRODUCTS IN WHICH YOU ARE INTERESTED

NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC

Carbon Sales Division, Cleveland, Ohio
GENERAL OFFICES
30 East 42nd Street, New York, N. Y.
BRANCH SALES OFFICES
New York, Pittsburgh, Chicago, St. Louis, San Francisco

HOW ALLIS-CHALMERS IN THE MODERN STRIP MILL

In this country's 28 wide strip mills, Allis-Chalmers equipment is playing a big part in keeping production rolling. The following table lists installations where Allis-Chalmers Motors, Motor-Generator Sets and Control help the industry meet production schedules . . . cut operating and maintenance costs to a minimum.

ALLIS-CHALMERS EQUIPMENT IN AMERICA'S 28 WIDE STRIP MILLS

Type of Mill	Motors and Control	Motor-Generator Sets
Hot Strip	9*	10
Cold Strip	11	20
Temper Pass	29	31

*Three mills have roughing mill motors only.

Allis-Chalmers builds main roll motors of any capacity or type for any installation . . . with low inertia armature design where required for faster response to automatic control.

Equally important, Allis-Chalmers Lo-Maintenance Motors are engineered for heavy-duty service. Husky all-around construction . . . with no skimping on materials . . . gives you a motor with *more than just a rated horsepower.*

Announce Regulex Control

For hot or cold reversing and temper pass mills, Allis-Chalmers has developed a new improved control—the "Regulex"—a constant regulating d-c machine for automatic mill control. This device is equally adaptable to cleaning and cutting line controls.

The new control automatically holds either constant current, voltage, speed or tension, independent of the percent reduction. Tension is held constant at stand-still . . . during acceleration and deceleration . . . under normal running.

NEW REGULEX EXCITER

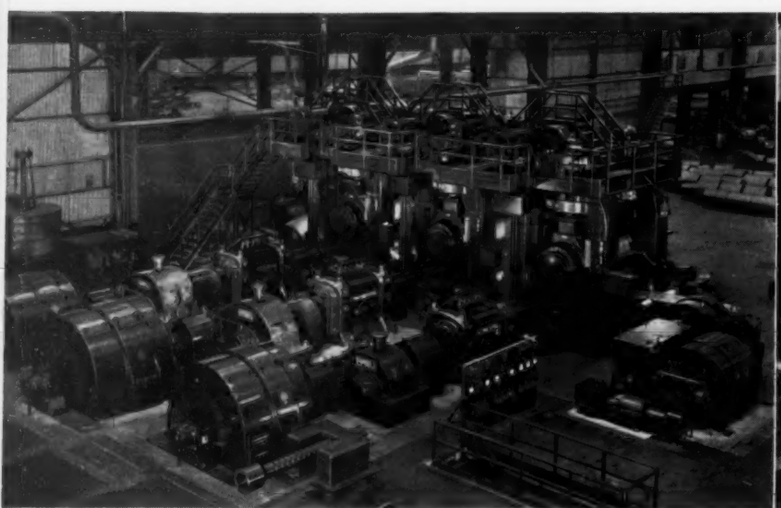
Designed to accelerate as high as 165 fpm per second, the "Regulex" cuts down scrap by reducing loss on each end of the strip. And the high-speed operation permits increased tonnages.

But don't take our word for the advanced engineering behind Allis-Chalmers Motors and Control. Those figures in the table speak for themselves—they prove that steel mill operators all over the country have confidence in Allis-Chalmers equipment.

A Precision-Engineered Line

Remember, too, Allis-Chalmers builds a precision-engineered line of auxiliary mill equipment — vertical lift and horizontal draw-out metal-clad switchgear, single and multi-tank mercury arc rectifiers, blast furnace, converter and coke oven exhausting turbo-blowers, synchronous condensers, transformers, circuit breakers, general purpose a-c and d-c motors and Texrope V-belt Drives, centrifugal pumps, turbo-generators and steam condensers.

For detailed information on any Allis-Chalmers equipment for the modern steel mill, call the district office near you. Or write direct to Allis-Chalmers, Milwaukee. A-1414



One 3500 hp and two 2500 hp Allis-Chalmers Motors drive this 84" three-stand tandem cold mill.

Delivery side of an Allis-Chalmers-driven 48" temper pass mill, showing two 500 hp and one 150 hp motors.

ALLIS-CHALMERS

MILWAUKEE · WISCONSIN

DISTRICT OFFICES IN ALL THE PRINCIPAL CITIES

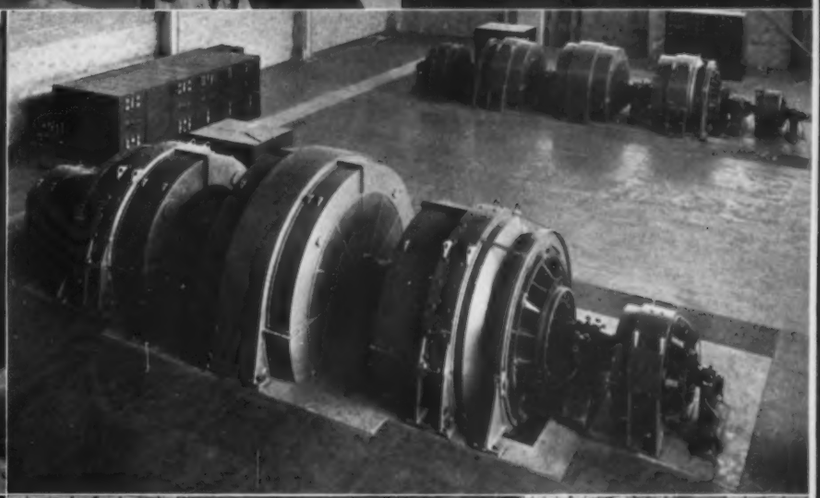
Atlanta, Ga.	Healey Bldg.
Chattanooga, Tenn.	Chat. Bk. Bldg.
Knoxville, Tenn.	Hamilton Nat'l. Bk. Bldg.
Baltimore, Md.	Baltimore Trust Bldg.
Birmingham, Ala.	First Nat'l. Bk. Bldg.
Boston, Mass.	Park Square Bldg.
New Haven, Conn.	157 Church St.
Buffalo, N. Y.	Liberty Bank Bldg.
Rochester, N. Y.	Roch. Gas & Elec. Bldg.
Syracuse, N. Y.	935 Hiawatha Blvd., E.
Charlotte, N. C.	Johnston Bldg.
Chicago, Ill.	135 South La Salle St.
Davenport, Iowa	Central Office Bldg.
La Porte, Ind.	1001 Lincoln Way
Rockford, Ill.	Gas-Electric Bldg.
Cincinnati, O.	Chamber of Com. Bldg.
Charleston, W. Va.	401 Knight Bldg.
Cleveland, O.	Nat'l. Broadcast Co. Bldg.
Dallas, Tex.	1800 N. Market St.
Denver, Colo.	Continental Oil Bldg.
Detroit, Mich.	Ford Bldg.
Grand Rapids, Mich.	As. of Com. Bldg.
Jackson, Mich.	Con. Power Co. Bldg.
El Paso, Texas	Mills Bldg.

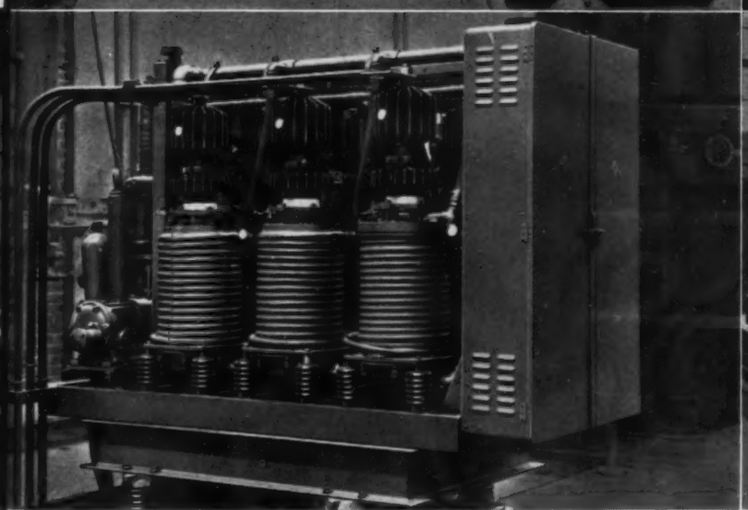
EQUIPMENT *Plays its Part*

AT RIGHT: Three Allis-Chalmers 5000 hp, 600 volt, main roll drive motors for a 100" hot strip mill.

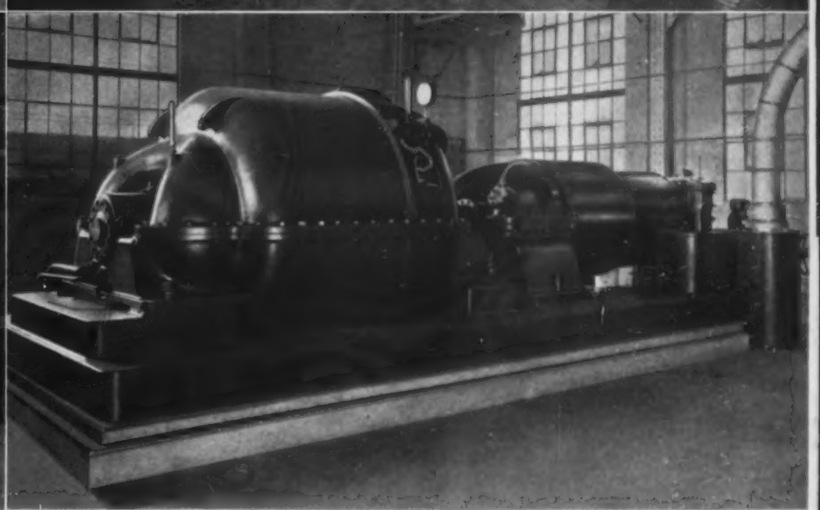
BELOW (Left): 80" hot strip mill motor room, showing 4500 hp Allis-Chalmers finishing mill motors, 6,000 kw motor-generator sets and control.

BELOW (Right): Supporting main roll motors of tandem cold mills—two 5-machine Allis-Chalmers Motor-Generator Sets, rated 6225 kw and 3575 kw.





Allis-Chalmers Excitron Mercury Arc Rectifier, rated 1250 kw at 600 volts d-c.



Allis-Chalmers Blast Furnace Blower handles 40,000 cfm of air at 30 lb. G.

Houston, Texas	1719 McKinney Ave.	New York, N. Y.	50 Church St.	Salt Lake City, Utah	Kearns Bldg.
Indianapolis, Ind.	Merchants Bank Bldg.	*Albany, N. Y.*	*75 State St.*	San Antonio, Tex.	Frost Nat'l. Bk. Bldg.
Louisville, Ky.	*U. S. Trust Bldg.*	*Newark, N. J.*	*1060 Broad St.*	San Francisco, Calif.	Rialto Bldg.
Kansas City, Mo.	Waldheim Bldg.	Philadelphia, Pa.	Broad St. Station Bldg.	Seattle, Wash.	Henry Bldg.
Omaha, Nebr.	*9th & Farnam St.*	*Harrisburgh, Pa.*	*40 So. Cameron St.*	*Spokane, Wash.*	*S. 151 Madison St.*
Wichita, Kan.	*239 North Rock Island*	Pittsburgh, Pa.	Koppers Bldg.	Tampa, Fla.	405 S. Morgan St.
Los Angeles, Calif.	Rowan Bldg.	*Youngstown, Ohio*	*211 N. Champ St.*	Toledo, O.	Toledo Trust Bldg.
Milwaukee, Wis.	West Allis Works	Portland, Ore.	1311 S.E. Union Ave.	Tulsa, Okla.	320 East Archer St.
Duluth, Minn.	*Bradley Bldg.*	Richmond, Va.	Richmond Trust Bldg.	*Oklahoma City, Okla.*	*901 W. Grand*
Minneapolis, Minn.	Foshay Tower	St. Louis, Mo.	Railway Exchange Bldg.	Washington, D. C.	Southern Bldg.
New Orleans, La.	Canal Bldg.	*Memphis, Tenn.*	*387 South Main St.*	Wilkes-Barre, Pa.	Miners Nat. Bk. Bldg.
Shreveport, La.	*City Bank Bldg.*				

ALLIS-CHALMERS A-C MILWAUKEE

The BONNOT-LENTZ BILLETEER *Smashes a Bottle Neck* IN STEEL PRODUCTION

The removal of surface imperfections from steel billets used to be performed entirely by means of hand tools. It was a slow, laborious job. Then along came the Bonnot-Lentz Billeteer to apply power to billet chipping; increase production; save time; and make men's work easier.

The Bonnot Company has placed no obstacles in the path of power throughout this machine. On the contrary, they have made it smoother by installing Timken Tapered Roller Bearings wherever power must pass. There are 164 Timken Bearings in the Bonnot Billeteer shown below, positioned as follows:

Roll Drive Shaft	30
Feed Roll Drive	4
Runout Roll Drive	4
Feed Rolls	48
Runout Rolls	48
Feed Reducer	8
Runout Reducer	8
Elevator Screw Mounting	4
Gear Reduction Drive for elevator	2
Tool Drive	4
Screw Drive	2
Roll Drive	2

Like machines of every description the Bonnot-Lentz Billeteer equipped with Timken Bearings is helping to keep the National Defense Program rolling.

THE TIMKEN ROLLER BEARING CO., CANTON, OHIO

Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

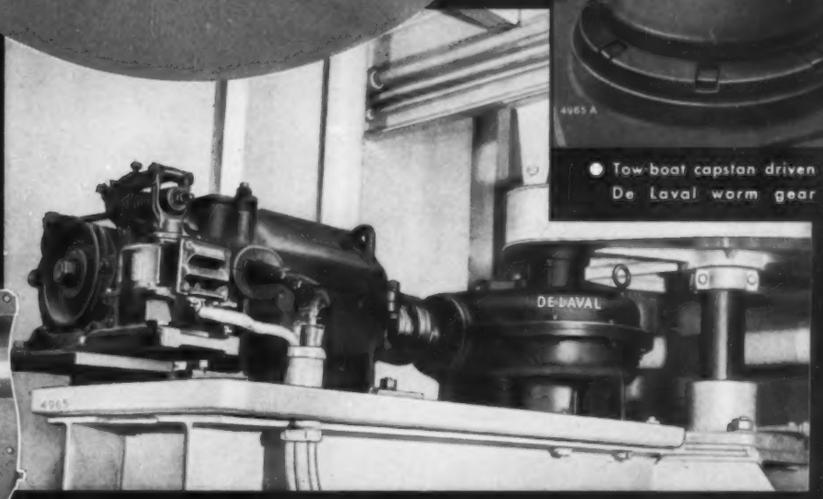
TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

Certainty of Operation

under severe conditions
is insured by specifying

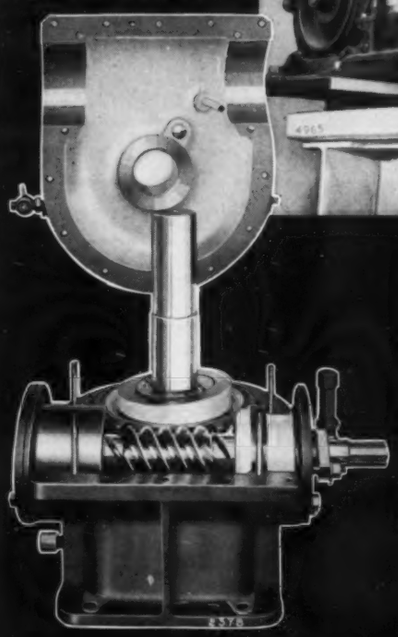
DE LAVAL
WORM GEARS
for speed
transformation

● Tow-boat capstan driven from De Laval worm gear . . .



● Motor drive through De Laval vertical drive worm gear and spur gear to capstan.

● Vertical drive worm gear with cover lifted.



OUR Engineering Department will select the proper combination of gears and characteristics to suit your conditions, including: number of reductions, ratios, center distances, pitch and number of threads, mechanical strength rating, heat rating, etc., utilizing the results of the long experience of an organization specializing in the design and quality production of worm gears and other speed transformers and their application in various industries.

. . . Ask for "De Laval Worm Gears in Industry," Publication W-1127.

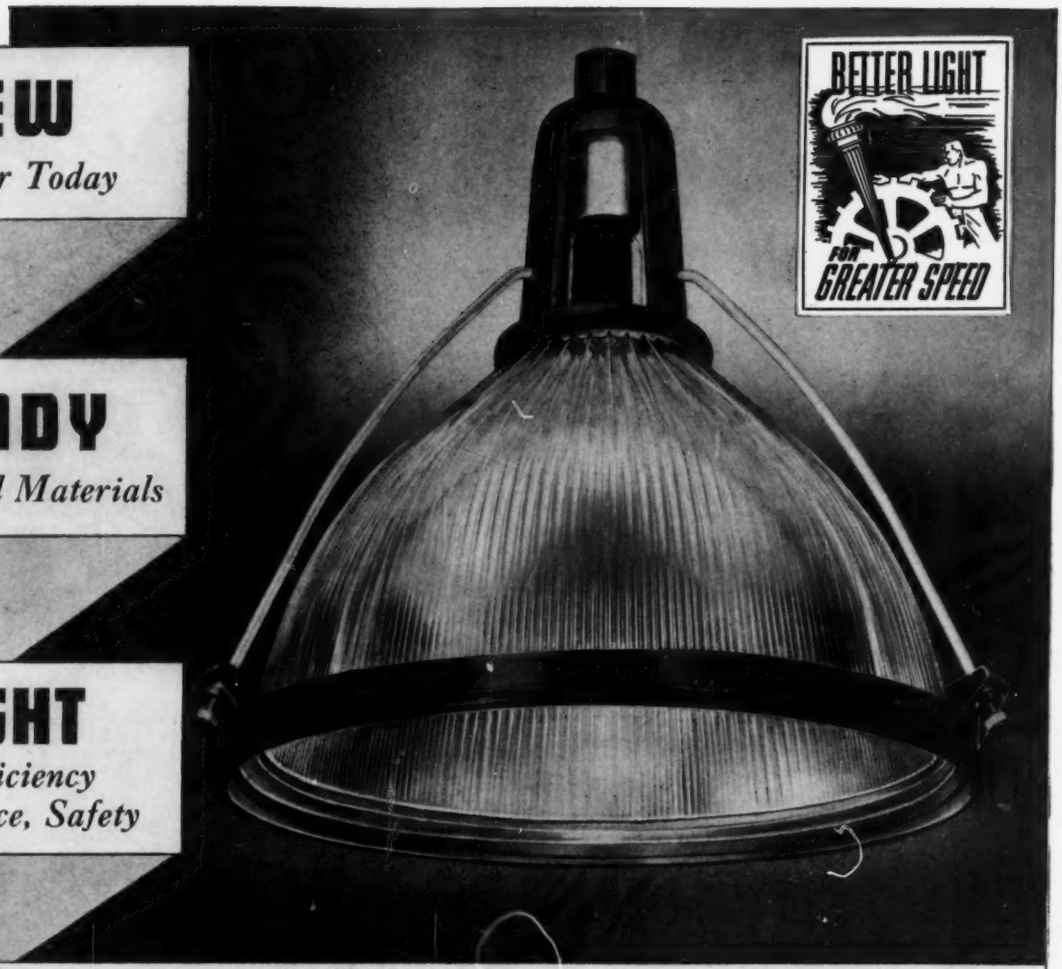
DE LAVAL
WORM GEAR DIVISION
of the De Laval Steam Turbine Co., Trenton, N. J.

MANUFACTURERS OF TURBINES . . . STEAM, HYDRAULIC; PUMPS . . . CENTRIFUGAL, PROPELLER, ROTARY DISPLACEMENT, MOTOR-MOUNTED, MIXED-FLOW, CLOGLESS, SELF-PRIMING; CENTRIFUGAL BLOWERS and COMPRESSORS; GEARS . . . WORM, HELICAL and FLEXIBLE COUPLINGS

NEW
Built for Today

READY
No Critical Materials

RIGHT
for Efficiency
Permanence, Safety



HOLOPHANE HIBAY REFLECTOR (500-1500 WATTS)

Today, Planned Lighting does its part in the fight for greater speed. With eyes working harder, working longer and under nervous tension, this new Holophane Unit is a timely aid to defense. It accelerates production schedules and reduces costly errors.

The Holophane Hibay Unit No. 990, illustrated here, is one of four new reflectors each with a different light distribution for uniform results under varying mounting conditions. The fact that these reflectors were designed and produced within the restrictions of the emergency is a tribute to Holophane research and engineering skill.

- **INVESTIGATE** *how conservation of materials, of power and of men can be advanced in your plant by the installation of new Holophane Hibay Reflectors. Write for details. No obligation.*

STUDY THESE ADVANTAGES:

1. Uses no critical defense materials
2. Standard Holophane construction . . . sturdy as a Cranelite.
3. Traditional Holophane efficiency, permanence, safety
4. No wattage limitations—maximum 1500 watt Incandescent or 400 watt Mercury
5. Common-sense high bay light distribution for high mounting

LOWER COST—FASTER SHIPMENT

Holophane
COMPANY, INC.
342 MADISON AVE.
NEW YORK CITY
Lighting Authorities—Since 1898
THE HOLOPHANE CO. LTD.
345 Yonge St. Toronto, Canada

Only through improved mechanization will industry find the 15 billion *additional man hours* needed to meet the requirements of our Defense Program . . . Men who watch the steel go by are establishing new production records with Morgan Continuous Rolling Mills because Morgan has always planned and built for the *future.*

R-92

MORGAN
WORCESTER
ENGINEERS AND
MANUFACTURERS

MORGAN CONSTRUCTION COMPANY • WORCESTER, MASSACHUSETTS

CLEANER MOTORS

Important!

Dirty, messy motor frames show that oil leaks or is thrown from bearings. Resulting short-circuits cause expense and delays that hold back production.

NON-FLUID OIL, drip-less and waste-less, stays where applied even where subject to heat and vibration. Clean motors mean clean armatures—burnouts are avoided. What's more, you save on oil and application cost for NON-FLUID OIL outlasts oil many times over.

Used successfully in leading iron and steel mills. Send for testing sample today—prepaid —NO CHARGE.

•

New York & New Jersey Lubricant Co.

Main Office: 292 Madison Ave., New York, N. Y.

WAREHOUSES:

Chicago, Ill. — Atlanta, Ga.
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TRADE MARK REGISTERED
NON-FLUID OIL
IN U.S. PAT. OFFICE & FOREIGN COUNTRIES

MODERN STEEL MILL LUBRICANT

Better Lubrication at Less Cost per Month

OHIO
Maximum Lift MAGNETS

A standard 65″ Ohio Magnet Lifting 5200 lbs. of Pig Iron

Standard round general purpose Ohio magnets are built in sizes from 12″ to 65″ in diameter.

Average lifting capacity for pig iron or scrap ranges from 200 lbs. to 6200 lbs.

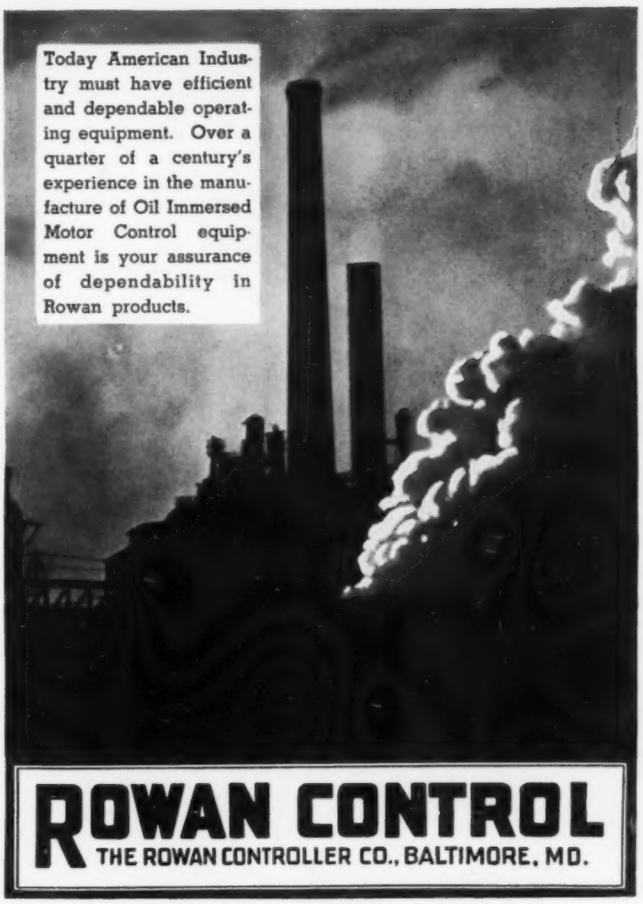
Depending upon the amount of material to be handled, the largest suitable magnet will do it most economically.

Labor cost per lift is the same whether the lift be 200 lbs. or 6200 lbs.

OHIO reliable MAGNETS

THE OHIO ELECTRIC MFG. COMPANY

5907 Maurice Ave. Cleveland, Ohio


Today American Industry must have efficient and dependable operating equipment. Over a quarter of a century's experience in the manufacture of Oil Immersed Motor Control equipment is your assurance of dependability in Rowan products.
ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

Speed-up for defense!... Cut production delays!

Periodic lubrication through

LINCOLN CENTRO-MATIC LUBRICATING SYSTEMS

will cut down bearing failures and prevent delays in producing defense orders

The Lincoln Centro-Matic System consists of a number of Centro-Matic Injectors--one for each bearing --and a suitable Centro-Matic Lubricant Pump . . . A push of a button, or a pull of a lever--and a measured amount of lubricant is instantly delivered to each bearing. Automatic and semi-automatic systems also available.

SEND for BULLETIN No. 888

There is a Centro-Matic System for every type of machinery requiring grease lubrication, and our engineering department will gladly assist you in the selection of the correct equipment for your needs... Write today.

141-8A

LINCOLN ENGINEERING COMPANY
PIONEER BUILDERS OF LUBRICATING EQUIPMENT
ST. LOUIS, MO.

WORLD'S GREATEST all around ELECTRIC TOOL

DRILLS—GRINDS—SANDS
SAWS—POLISHES
SHARPENS—CARVES

ONLY $8.95 POSTPAID
GUARANTEED FOR ONE YEAR

The new WHIZ ELECTRIC TOOL is the handiest power tool ever made. A rugged tool for power and precision work. Drills through ¼ inch iron plate in 42 seconds or engraves intricate designs. Handles any material: Metals—Woods—Alloys—Plastics—Glass—Steel—etc. Saves time. Eliminates labor. Plug into any socket AC or DC, 110 volts. Chuck ¼ inch capacity. Ball bearing thrust. Powerful, triple-geared motor. STANDARD MODEL, with Normal Speed (uses 200 different accessories, instantly interchangeable). **Price only $8.95.**

The only DRILL-TOOL with a full year's guarantee

FREE Accessory outfit (Value $2) includes set of drills, mounted 1½ inch grinder, sanding discs, cutting wheels, mounted brush, polishing wheel, carving burr, etc. FREE with each tool ordered NOW. We pay postage.

10-DAY TRIAL—MONEY BACK GUARANTEE

PARAMOUNT PRODUCTS CO.

Dept. 12-RAS 545 Fifth Ave. New York, N. Y.

NO. 9

ALUMINUM, DEFENSE, AND YOU

ALCOA

SIX MORE PLANTS IN FIVE STATES ON THE WAY

DEFENSE PLANT CORPORATION OWNS THEM. We've been designated to build them . . . fast.

Actually, when the names went on the dotted lines of the contract on August 19, we had already placed more than $16,000,000 worth of orders for some of the equipment and materials it takes longest to make and get.

FIVE OF THESE PLANTS will smelt aluminum. Their combined capacity is planned for more than 500,000,000 pounds a year, which is greater than the nation's entire production of aluminum in 1940. Locations: Massena, N. Y., Spokane, Wash., Troutdale, Ore., Los Angeles, and in the State of Arkansas.

The sixth plant will refine alumina from bauxite. Its billion-pounds-a-year capacity adds 58% to the nation's alumina capacity. It will be located at Bauxite, Arkansas.

HOW GOES CONSTRUCTION? At this writing, as fast as title is secured to the sites, contracts are being let for grading and foundations so as to be ready for the structural steel, which is coming as rapidly as it can be gotten.

What is more important, the aluminum plants are scheduled to deliver ingot by the summer of 1942; the refining plant to deliver alumina in early summer, 1942.

WE'VE ASSIGNED a large staff of men full time to headquarters engineering, purchasing, and accounting on this government building job.

We're sending competent and experienced management men out on these jobs as superintendents and other staff executives on construction, and for subsequent operation of such of these plants as we are designated to operate.

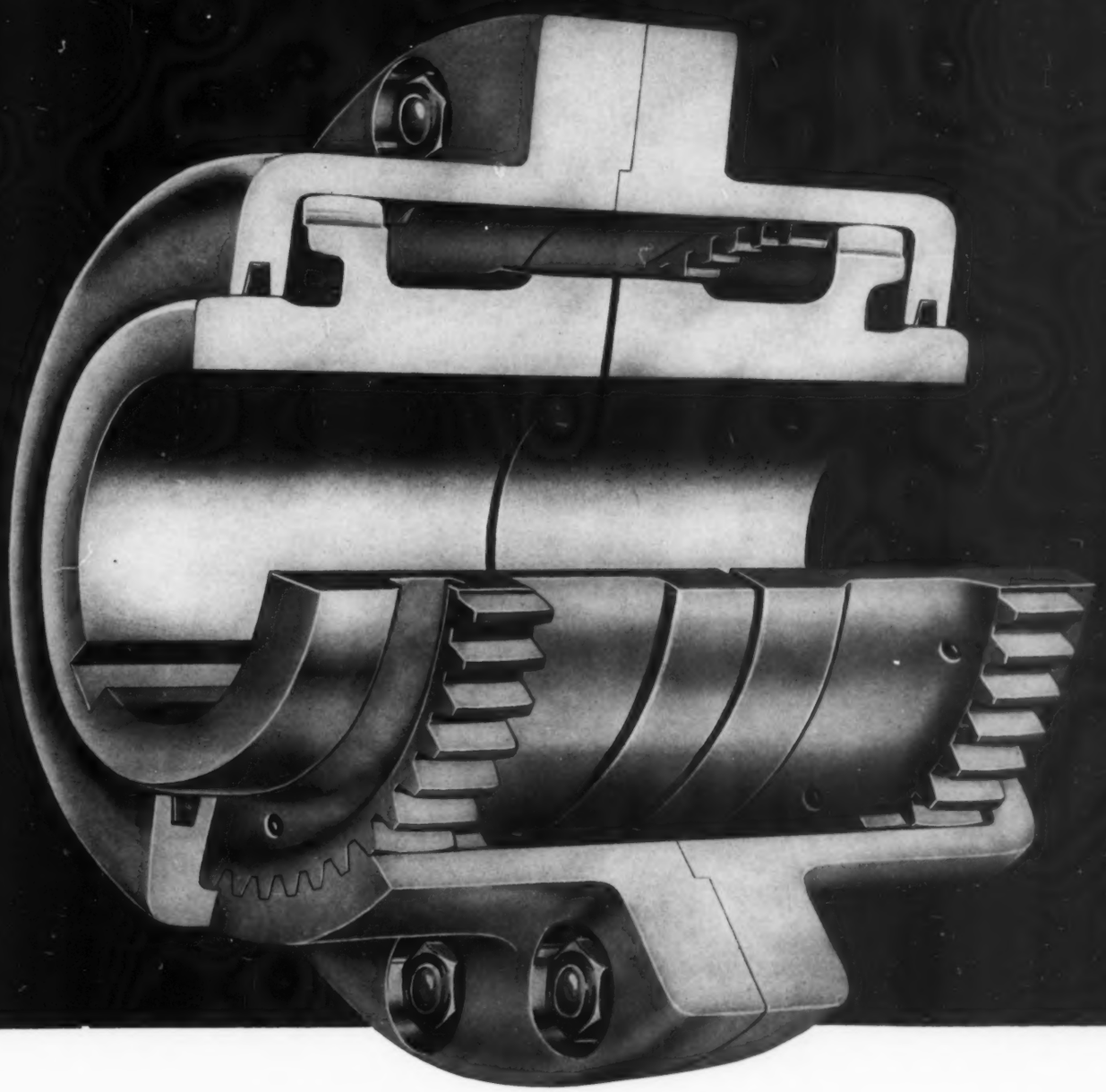
EVERY KNOWN IMPROVEMENT in design and construction and equipment is being incorporated in these plants. We intend that every dollar that will be spent shall be the best dollar's worth that experience can build. We do not make one cent of profit from this assigned job of construction.

We think we know how to get the government value-received for its money, because we are completing the expenditure of more than $200,000,000 of our own money in an expansion program which started after the beginning of the present war. Some of this expenditure is in new alumina and aluminum plants which will bring our own Alcoa capacity up to more than 700,000,000 pounds a year. The remainder is in tremendous expansion of facilities for fabricating every form of aluminum.

DEFENSE, GENTLEMEN, is getting its aluminum.

ALUMINUM COMPANY OF AMERICA

POOLE



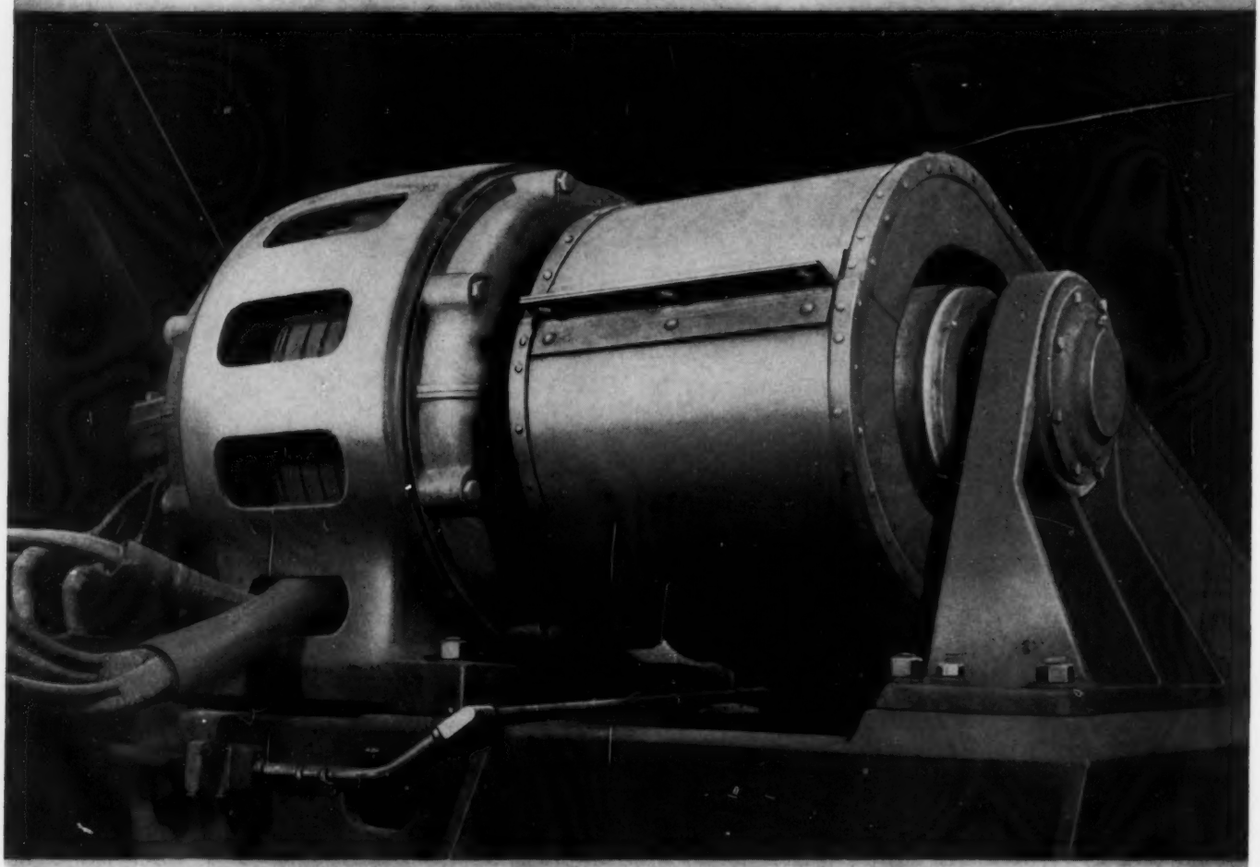
A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

WESTINGHOUSE

MOTORS



ON

"NORMA-HOFFMANN"

IN SUCCESSFUL OPERATION SINCE 1929

WESTINGHOUSE "CW" 3-BEARING HOT SAW MOTOR

300 HP-1450 RPM-30,000 LBS. BELT PULL

MOUNTED ON

NORMA-HOFFMANN PRECISION ROLLER BEARINGS—6½" MAX. BORE

NORMA-HOFFMANN PRECISION BALL BEARINGS FOR THRUST

GREASE LUBRICATED

Above are the pertinent facts relating to the application of NORMA-HOFFMANN PRECISION BEARINGS on the motor illustrated, at the Aliquippa Plant of Jones and Laughlin Steel Corporation. Because of the satisfactory service rendered thereby, Jones and Laughlin have recently applied NORMA-HOFFMANN BEARINGS to a number of similar motors.

Write for the Catalog. Let our engineers work with you.

NORMA-HOFFMANN BEARINGS CORPORATION, STAMFORD, CONN., U.S.A.